Medd. Serie I Hydrog.
LIBRARY
FISH & WILDLIFE SERVICE
PACIFIC OCEANIC FISHERY
INVESTIGATIONS

MEDDELELSER

FRA

KOMMISSIONEN FOR DANMARKS FISKERI- OG HAVUNDERSØGELSER

SERIE: HYDROGRAFI · BIND III

NR. 3. A. KIILERICH: THE HYDROGRAPHY OF THE WEST GREENLAND FISHING BANKS

KØBENHAVN
C. A. REITZELS FORLAG
BIANCO LUNOS BOGTRYKKERI A/S
1943

MEDDELELSER FRA KOMMISSIONEN
FOR DANMARKS FISKERI- OG HAVUNDERSØGELSER
SERIE: HYDROGRAFI · BIND III · Nr. 3 · 1943

THE HYDROGRAPHY OF THE WEST GREENLAND FISHING BANKS

BY

A. KIILERICH

KØBENHAVN
C. A. REITZELS FORLAG
BIANCO LUNOS BOGTRYKKERI A/S
1943

CONTENTS

Page

Introduction ... 3
I. Characteristics of the most important water masses ... 3
1. Cold water on the coasts of Greenland ... 3
2. Warm water on the coasts of Greenland ... 4
3. Mixed water ... 5
II. Survey of hydrographic conditions in Greenland waters ... 5
A. Polar Sea, Greenland Sea, Denmark Strait and the waters round South Greenland ... 5
B. Davis Strait, Disko Bay and Baffin Bay ... 10
1. The conditions of depth off West Greenland ... 10
2. The hydrography of Davis Strait ... 12
Cold water on the western coast of South Greenland ... 13
Warm water on the western coast of South Greenland ... 18
Velocity of the West Greenland current ... 20
Water transport of the currents ... 21
3. Hydrography of Disko and Baffin Bays ... 22
III. The hydrographic conditions of West Greenland in different years ... 23
Litterature ... 42
Dansk Resumé ... 44
Plates ... 47

Introduction.

The hydrographic conditions of the Greenland seas are dominated by the occurrence of water masses of quite different origin and consequently of different temperatures and salinities; this particularly is an area which shows the greatest variations, both regular from season to season and irregular during shorter or longer periods.

Even more than hundred years ago the first hydrographic observations were made by expeditions to Greenland waters, and later on practically every expedition has brought home observations, at the beginning few, scattered and casual, but later coherent series attained by following a definite plan.

From most of the expeditions the material collected has been published in a worked out form giving thus a survey of the hydrographic conditions within the areas visited by the expedition in the year concerned. However, a complete treatment of all the material available has been carried out by J. N. Nielsen (1928) only, but as his work is only carried up to and including the "Tjalfe" expeditions of 1908 and 1909 we are able now to supplement his results on many points, and are further able to demonstrate the great change of natural conditions which has appeared in the arctic region during our century (see e. g. Ad. S. Jensen 1939).

Thus the object of the present paper is to report on the main results of a complete treatment of all the observations available from the Greenland seas from about 1880 till to-day, with special regard to verification of the regular annual variations in the hydrographic conditions near the coastal banks off West Greenland and of the irregular, very slow changes which, in these places, have been found within the last 60 years, as above mentioned.

I. Characteristics of the most important water masses.

The different water masses which prevail on the coasts of Greenland are specified in the following survey with a statement of the usual temperature and salinity boundaries as far as these can be established.

1. Cold Water on the coasts of Greenland.

A. The East Greenland Polar Current.

a. In Greenland Sea: $+1.5°$ C.—$+1.7°$ C. salinities: 33.50—34.00 ‰.
Vertical extension: 250—350 m.

Temperature minimum at 40—60 metres depth: ÷ 1.7° C. salinities: 33.50—34.00 ‰.
Lower limit: 0° C. salinity: 34.75 ‰.
Outer limit at the surface: salinity abt. 32 ‰, varying temperature.

b. In Denmark Strait: 0° C.—÷ 1.65° C. salinities: 32.50—34.00 ‰.
Vertical extension: 100—200 metres.
Temperature minimum at varying depths: abt. ÷ 1.5° C. with salinities 33.00—34.00 ‰.
Lower limit: 0° C: salinities: 34.00—34.50 ‰.
Outer limit at the surface: salinity abt. 34 ‰, varying temperature.

c. At Cape Farewell: early summer: 0° C.—÷ 1° C. with salinities: 33.00—34.00 ‰.
End of summer: abt. 0° C. or 0° C.—4° C. with salinities 32.00—34.00 ‰.
Vertical extension: 100—150 metres.
Temperature minimum at 10—60 metres depth.
Lower limit: The bottom inside the banks.
Outer limit at the surface: salinity 34.00 ‰, varying temperature (30—50 nautical miles broad).

d. In Davis Strait as far as Lille Hellefiske Bank.
Early summer: ÷ 0.5° C.—+ 1° C. (at the highest 2°) salinities: 33.00—33.75 ‰.
End of summer: 1° C.—4° C. salinities 31.50—33.50 ‰.
Vertical extension: to 150 metres.
Temperature minimum at 30—130 metres depth.
Limits: salinity abt. 34.00 ‰ but variable.

B. The Canadian Polar Current.

At the entrance of Davis Strait: ÷ 1° C.—÷ 1.7° C. with salinities 33.50—34.25 ‰.
Vertical extension in the middle of the Strait: 200—300 m.
Lower limit: abt. 0°; abt. 34.25 ‰.
May touch the slope of the Hellefiske Banks at 50—100 m depth with 0° C.—1° C. Salinities 33.50—34.00 ‰.

C. Cold Water from the Winter.

a. Over the Hellefiske Banks: ÷ 1.3° C.—+ 1.0° C. with salinities 33.50—34.25 ‰.
b. Over banks further south: 0° C.—1° C.; salinities 33.50—34.00 ‰.

2. Warm Water on the Coasts of Greenland.

A. Undercurrent in the Greenland Sea.

0.5° C.—2.0° C.; salinities 34.90—34.98 ‰.
Temperature maximum in about 200 metres depth.

B. Irminger current.

a. In Denmark Strait.
Upper layers later in the summer: 6° C.—9° C. with salinities 35.00—35.20 ‰.

b. At Cape Farewell.

Early summer: Upper layers (100—200 metres depth). 3°—5° C., salinities 34.00—34.75 ‰.

Central part (200—400 metres depth). 4° C.—5° C., salinities 34.75—35.00 ‰.

End of summer: Upper layers (100—200 metres depth). 6° C.—8° C. salinity a little lower.

Central part. (200—400 metres depth). 5° C.—6° C. salinity a little lower.

c. The undercurrent in Davis Strait.[1])

300—700 metres depth: 3.5° C.—5.0° C. salinities: 34.75—35.00 ‰.

3. Mixed Water.

A. "Polar front water" in Denmark Strait.

2.25° C.—5.0° C. salinities: 34.60—34.90 ‰.

Generally at 100—250 metres depth.

B. "Subarctic Mixed Water".

a. Irminger Sea: a little more than 3° C. salinity abt. 35 ‰.

b. In Davis Strait: 3.05° C.—3.50° C.: with salinities 34.87—34.90 ‰.

C. The West Greenland Current over the Hellefiske Banks.

Early summer: 1° C.—3° C.; salinity abt. 34 ‰.

Later in the summer: 3° C.—5° C.; salinity abt. 33 ‰.

II. Survey of hydrographic conditions in Greenland Waters.

A. Polar Sea, Greenland Sea, Denmark Strait and the waters round South Greenland.

The Polar Sea is situated north of both continents of the northern hemisphere. In 3 places it is connected with the Pacific and the Atlantic, viz. through the narrow and shallow Bering Strait, the narrow sounds north and northwest of Baffin Bay, and the open water between East Greenland and Norway. The latter connection is more than 1000 kilometres broad, and here an interchange of water takes place which is of the greatest importance both for the Polar Sea and the Greenland Sea, Denmark Strait and the West Greenland water. Between the Faroe and the Shetland Islands the largest branch of the Gulf current enters the Norwegian Sea, where it follows the western coast of Norway and finally its offshoots enter the Polar Sea, partly round the North Cape partly west round Svalbard.

We know but little of the central part of the Polar Sea. More than half the sea is constantly covered with ice several metres thick, below which is a cold water layer with low salinity in comparison with Atlantic water. This water layer reaches a depth of 100 to 200 m. The minimum temperature is rather close to the surface (40—60 m) but a water layer of more than 100 m depth has a temperature of $\div$ 1.7° or lower.

[1]) Most of this water is, however, mixed with water from the polar current.

Greenland Sea. The upper layer of cold water of the Polar Sea, and with it the ice, are moving slowly west towards the open water between Svalbard and Greenland. In some years the motion in this direction is stronger than in others and the ice floes may actually lie pressed together in against Greenland, and thus carry much ice to the East Greenland current, and in others the ice may, on the contrary, be forced more to the east and thus gather especially in the area off Wrangel Island and Bering Strait. However, the deep areas of the Polar and Norwegian Seas are separated by a ridge, over which, according to the latest investigations, the depth of water is 1100—1500 m[1]) but as the polar current is a pronounced surface current it is able freely to leave the Polar Sea and flow south along the eastern coast of Greenland.

The shelf along the Greenland Sea is generally a little more than 100 nautical miles broad and the polar current keeps close to it. The velocity of the current is greatest at the surface; and above the edge of the shelf it reaches 10—20 cm sec^{-1}, but above the shelf itself hardly more than 5 cm sec^{-1}. Close to the coast the polar current reaches a depth of 250—300 m, while its depth above the border of the shelf is only 150—200 m.

The temperature of the uppermost layer of the polar current is usually negative, but in the summer it may be found to be positive in the spaces between the floes and may even reach about 2°. Of course the salinity of the surface water is low and is the same as in the Polar Sea (30—32 ‰) and the 32 ‰ isohaline in the surface layer may possibly be considered as the eastern boundary of the polar current. The minimum temperature, which is usually found to be near the freezing point of the water (÷ 1.7— ÷ 1.8°), lies in 40—60 m depth, as in the Polar Sea. This corresponds to salinities of 33.50—34.00 ‰ in the outer part of the current. The lower limit of the current may be drawn at the 0° isotherm and the 34.75 ‰ isohaline, which two nearly always coincide. Due to heating from above and admixture from below the vertical extension of the polar current is reduced the further it flows south, and also during the summer.

Below the polar current, and partly outside it, a layer of relative warm and salt water is encountered. This was demonstrated for the first time by C. Ryder in 1891[2]) and he at once put forward the right explanation for this fact viz. that this is a part of the branch of the Gulf current which runs up along the western coast of Svalbard and here turns southward off East Greenland between the cold water masses of the polar current and of the Norwegian Sea. The temperature of this warm current has been variously recorded by different expeditions viz. from 0.4° to 2.15° C., but this corresponds well with the fact which Sverdrup has demonstrated, that from year to year great oscillations take place in the extension of the Atlantic water north of Svalbard. The horizontal extension of the polar current off East Greenland is subject to great oscillations also.

We know less of the hydrographic conditions in the part of the Greenland Sea lying south of 74° N. but in this area the east Iceland polar current branches off and flows south east, where it enters the Norwegian Sea between Jan Mayen and Iceland, its influence here being stronger in some years than in others.

Denmark Strait and the waters round South Greenland.

Across the northern part of Denmark Strait the submarine ridge passes from Iceland in a westnorthwest direction to Greenland a little north of Angmagssalik. Over the greater

[1]) H. U. Sverdrup 1933, P. Shirshov and E. Fedorov 1938.

[2]) C. Ryder 1895.

part of the ridge the depth of the water is 300—400 m, but a little way east of the middle a narrow channel about 550 m deep cuts its way right across.

This submarine ridge effectively separates the water masses of the northern and southern depths, and, on account of its varying depths, gives rise to a strong eddy formation and mixture of water masses of different origins.

While the greater part of the East Greenland polar current passes over the ridge fairly freely, the warm undercurrent from the Greenland Sea is more or less completely stopped. Most likely the greater part of the water from this current turns east, where it can be traced north of Iceland and the Faroes[1]) but larger or smaller quantities may now and then cross the ridge and contribute to the formation of bottom water in the southern part of Denmark Strait,[2]) or it is whirled up to become part of the mixture between the water masses of the Polar current and the Irminger current.

Whether a greater or smaller part of this warm undercurrent from the Greenland Sea passes over the ridge, it is fully replaced by the Irminger current, this current being so vigorous that it alone carries warm water to the south and west Greenland sea regions. Though by origin a surface current it reaches a considerable depth, and having joined the East Greenland current its original characters are preserved best in its somewhat deeper parts.

The border line between the cold East Greenland current with low salinity and the warm salt water of the Irminger current lies in the middle of the strait a little south of the highest part of the ridge, but on account of the topography of the sea bottom such a strong eddy formation arises that the characteristic qualities of the polar current are very considerably reduced as early as at the northern portion of the Strait.

Further south along the coast of Greenland the border line between the warm and cold currents, lies in the vicinity of the slope of the shelf. In this area also a strong eddy formation is to be found, according to BÖHNECKE's account[3]) like the whirls along the polar front of the atmosphere; possibly however a part of the whirls are due to the outline of the sea bottom and are therefore stationary.

On account of this mixture some of the atlantic characters of the upper layers of the Irminger current are lost of course, but as its water masses are far greater than those of the polar current, the reduction of temperature and salinity takes place slowly. The horizontal extension of the current in the uppermost water layers is extraordinarily great, and we must go as far as to the middle of the strait to find a salinity lower than that characteristic of the current (less than 35.00 ‰).

Near the south point of Greenland a part of the current, it is supposed, branches off towards the south east, to take part in a cyclonic rotation in the southern part of the Denmark Strait (often called Irminger Sea) but a very considerable part of the current rounds Cape Farewell and flows northwards into the Davis Strait.

During the summer the surface temperature often reaches 6—9° C. in the northern part of the strait, and the salinity is always found to be more than 35.00 ‰, often up to 35.20 ‰. On its southern course along the coast, the temperature does not decline much, but the salinity is distinctly reduced. Off Cape Farewell in the uppermost 100 or 200 m where the

[1]) J. N. NIELSEN in "Greenland" 1928.
[2]) FR. NANSEN 1912.
[3]) G. BÖHNECKE a. o. 1930, 1932.

greatest admixture of polar water takes place, the warm current has a temperature and salinity of 3—5° C. and 34.00—34.75 ‰ in the beginning of the summer, but the core of the current is found at some depth — in warm years at 200—400 m and in cold years somewhat deeper — and here the temperature is 4°—5° C. and the salinity 34.75—35.00 ‰ as a rule. In the upper water layers the temperature rises to 6°—8° C. during the summer and deeper down to 5°—6° C., but the salinity will often show somewhat lower values.

Between the warm current and the east coast of south Greenland the polar current cuts in, characterized by low temperature and salinity. At the northern boundary of Denmark Strait its extension is still so great that it fills up about $^4/_5$th of the whole strait; but as soon as it has passed over the crest of the ridge it is forced strongly westwards. Here, its temperature is as low as $\div 1.5°$ C. and the salinity is 33—34 ‰.

In the northern part of the strait the outer limit of the polar current coincides with the ice boundary and the isohaline for 34.00 ‰, but the temperature of the surface water may vary somewhat from year to year. Just as in the Greenland Sea the 0° isotherm may be used for the lower limit, this isotherm lying between the 34.00 and 34.50 ‰ isohalines and the vertical extension of the polar current is generally 100—200 m.

Southward off the coast the polar current is very narrow and keeps fairly over the shelf itself, which is 15—30 nautical miles wide, but on account of the strong eddy formation and mixing with the warm water of the Irminger current, it is difficult to state its precise border. Till well on in the summer the polar current carries water of negative temperature, but while this cold water layer in the north reaches a depth of 100 to 200 m, it is not deeper than 30 to 50 m in the south and keeps very close to the coast. During the summer the current receives such a supply of heat that in many cases no negative temperature occurs to the south.

Rounding Cape Farewell the polar current may roughly be characterized as follows: in the upper water layers the temperature is negative nearly throughout the width of the current at the beginning of the summer, but towards the end of the summer the water is heated so much that the negative temperatures are found only in a small area close to land, and they may even quite disappear. In some years the temperature rises even to 2°—3° or 4° C. in water which, all the same, must be classed as polar current water on account of its movement and salinity. The usual salinity is 32—34 ‰, and if we here too use the 34.00 ‰ isohaline as the limit of the polar current its width is 30—50 nautical miles in the upper layers. At a greater depth it does not extend quite so far from the coast, but nearly always so far that it touches the coastal banks.

All the water which passes Cape Farewell to continue north along West Greenland, thus originates partly from the Irminger current and partly from the East Greenland polar current; but the two currents have already been mixed so strongly along the eastern coast that the masses of polar current water or Atlantic water which reach so far are very small compared with the mixed water. This perhaps especially refers to the Irminger current, as its outer unmixed part gives water to the circulation south east of Greenland. Accordingly, mixed water constitutes, not only the main part of the West Greenland current, but especially exactly that part of the current which, off the western coast is considered as warm water of Atlantic origin. In reference to the origin of this mixed water it has been termed "polarfront water".

A thorough investigation of the character of the mixed water in its course in Denmark Strait shows that in summer its temperature and salinity in the northern part of the area is 2.25—4.25° C. and 34.60—34.90 ‰, in the southern part 3.50—5.00° and 34.60—34.93 ‰, but these values cannot be attained by a mixing of the polar current and the Irminger current only, besides this mixture, water with rather low temperature and salinity originating from the warm undercurrent from the Greenland Sea to a lesser degree forms a part of the mixed water. Thus this last off-shoot from the Svalbard branch of the Gulf current in some years at any rate is able to contribute to the hydrography of West Greenland.

The velocity of the East Greenland current is everywhere greatest on the slope of the shelf and low on the shelf itself, and also greater in summer than in winter. The velocity of course changes much from year to year, but the values found in summer on the shelf itself are generally about 5 nautical miles in 24 hours and 10—20 nautical miles outside.

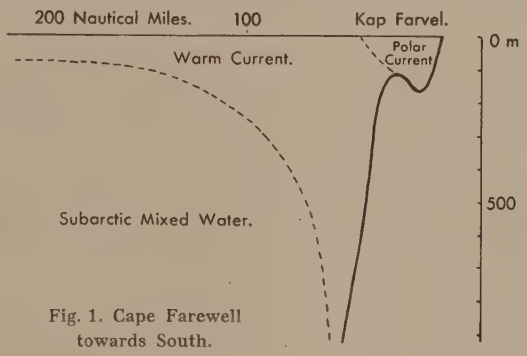


Fig. 1. Cape Farewell towards South.

A considerable part of the ice which the East Greenland current carries southward originates from the Polar Sea proper where the ice of several years reaches a thickness of 2—4 metres without piling up.

The Greenland Sea also is frozen up in winter and the ice may be 1—1½ metres thick. It is certain that the whole layer of ice moves slowly southward during the winter; but its speed increases when the spring comes on, and in the middle of the summer the ice from the fjords joins it.

Drifting southwards the ice-belt becomes more and more narrow due to melting. Part of the ice, it is true, flows with the East Iceland polar current towards the southeast, but the greater part by far is carried with the Greenland current southward through the Denmark Strait. Off the coast of South Greenland the ice is broken up owing to currents and eddies, but besides this the melting has proceeded so far that most of the ice originating from the Greenland Sea has disappeared; almost all ice rounding Cape Farewell is from the Polar Sea itself.

At the end of the summer the influx of ice from the north is ceasing and the Sea off Angmagssalik may be more or less free from ice (August to October). Later in the autumn (November) the Storis[1]) reappears and periodically is joined completely to the coastal ice. Generally this Storis reaches Cape Farewell near the middle of January and the influx of ice continues till late in the summer, so this is ice which has broken up in the Polar Sea or Greenland Sea the previous summer.

Outside these two main currents, the polar current and the Irminger current, i. e. in the Irminger Sea, we find again water masses with lower temperature than the water of the warm current. They may sometimes be covered with a thin layer from the Irminger current, but the main water layer is reached at a small depth where the temperature is very constantly a little more than 3° C. and the salinity about 35.00 ‰. This water layer has been

[1]) Storis = Sea-ice carried to Davis Strait by the East Greenland polar current.

named "subarctic mixed water" by various investigators, but the opinions of its origin have differed somewhat. However, it has been proved that the water in the southern part of Davis Strait has nearly the same characters, and that these two areas are connected by a broad and deep current which quite slowly flows eastwards just outside the bend of the Greenland current.

The established fact of this great coherent area of cold mixed water is most interesting because, being situated round the southern point of Greenland, it prevents a direct inflow of atlantic water from the central part of the Atlantic to West Greenland. So, all the relatively warm water of atlantic origin which flows northward along West Greenland must have come from the East Greenland current, and with it have rounded Cape Farewell.

The limit between the warm current and the cold subarctic water is oblique south of Cape Farewell and the cold water thus wedges in under the warm and, at a depth of 700—1000 m, approaches the coast rather closely, while it does not reach the upper water layers till a distance of 150—200 nautical miles from land (fig. 1).

B. Davis Strait, Disko Bay and Baffin Bay.

1. The conditions of depth off West Greenland.

Off the greater part of the coast of West Greenland a row of banks is situated of which Fyllas Bank and the Hellefiske Banks have been known for more than half a century while others were not discovered till lately.

Fyllas Bank is the smallest and best defined of the banks which are of importance for the fishery. It is situated off Godthaab at a distance of about 15 nautical miles from the coast, is 15—20 naut. miles broad, and its extension north to south is about 45 nautical miles. In the greater part of the area the depth is about 50 metres, and the bank slopes steeply on all sides towards greater depths, and is separated both from the coast and from Lille Hellefiske Bank by channels 200—500 metres deep.

The name Lille Hellefiske Bank is generally used for a system of banks separated from Fyllas Bank by a channel hardly 15 nautical miles broad; it extends northward to the channel which cuts in south of Store Hellefiske Bank a little south of Holsteinsborg. The length of the bank from south to north is thus more than 100 nautical miles, and its breadth is on an average about 50 nautical miles. This system of banks is far less well defined than Fyllas Bank, and the greatest areas by far are found at a depth of about 100 m or a little less. Two parts of the southern part of the bank reach the same height as Fyllas Bank (about 50 m) viz. the southernmost point of the bank and a part close southwest of Sukkertoppen, this part of the bank also resembles Fyllas Bank because it too is separated from the coast by rather deep water. North of this part an area with somewhat deeper water (about 150 m) passes the bank, making, to some degree the northern part independent of the rest. The water over this part is mostly 60—100 metres deep, and no channel with deep water appears in front of the coast. As the hydrographic conditions of the two areas of the bank differ somewhat they have in recent years been considered as two independent banks each with a name: Lille Hellefiske Bank represents the southern part of the bank situated southwest of Sukkertoppen, and Helders Bank is the name for the northern part situated off Evighedsfjord and Søndre Strømfjord.

Fig. 2. Bathymetric map showing the banks West of Greenland.

Store Hellefiske Bank covers a very great area, as it extends from a little south of Holsteinsborg to Egedesminde and its width from the coast to the outer edge (the 200 metre line) is about 60 nautical miles. The depth is found to be 100 metres over the whole outer half of the bank, but nearer the coast there are series of shallow parts with water only 30—50 m deep. Quite close to the coast we find depths of 200—500 m inside the northern part of the bank; but further south there is apparently no such channel.

Store Hellefiske Bank passes westwards to join the submarine ridge which separates Davis Strait from the depths of Baffin Bay.

Besides these three areas of banks further south other systems of banks appear, but of lesser area. Northwest of Fiskenæs the Fiskenæs Bank is situated with a water depth of 40—80 m and separated from this bank by a submarine fjord, and southwest of Fiskenæs there is another, but less well bounded area, Danas Bank. Further south lies the Frederikshaab Bank and finally in 1928 a small bank unknown hitherto was found about 25 nautical miles westsouthwest of Cape Farewell, on which a depth of 127 metres was measured.

Close outside this row of banks the sea bottom in the southern part of Davis Strait slopes precipitously to 2000 m, further south it slopes to even more than 3000 m. North of the latitude of Godthaab the depth in Davis Strait is everywhere less than 2000 m, and apparently the depth varies irregularly here, and we may, in many places outside the banks proper, find parts of the sea bottom raised much higher than the surroundings. This for instance refers to the area outside Fyllas Bank and southwest of Store Hellefiske Bank, and no doubt such deep lying banks influence the currents, even in the upper water layers.

The row of banks also continues north throughout the whole of Baffin Bay in front of the Greenland coast. The southernmost and largest bank is the Disko plateau, separated from Store Hellefiske Bank by a 400 m deep channel, which passes into Disko Bay where the depths are very irregular. No channel separates this shallow plateau west of Disko Island from the coast. Its westward width is about 45 nautical miles as far as the 200 m line, while southwestward a tongue of the bank goes as far as 90—100 nautical miles out from the island. On account of this tongue the connection between Disko Bay and Baffin Bay is very narrow, and this has great influence in several ways on hydrographic conditions.

Outside the banks the sea bottom slopes rather evenly to the central part of Baffin Bay where depths of more than 2000 m are found. In the northern part of Baffin Bay the depths are smaller (less than 1000 m) and further south considerable areas of banks appear off the Canadian coast.

In the deeper lying parts of Smith Sound the depth is 500—700 m, with the exception of a deep passing from Inglefield Gulf through Whale Sound and a little way southward, in which the depth is 800—950 m.

2. The Hydrography of Davis Strait.

Plate IV and V show the topography of the sea surface calculated on the basis of a deep lying reference level and the corresponding currents along the surface of the sea, computed on the basis of observations from the "Godthaab" expedition of 1928. The reference level has, in different parts of Davis Strait, been placed at such a depth (from 2250 to 660 db) that there is a suitable balance between the water masses which from north and from south

pass the sections. We see that both the East Greenland polar current and the Irminger current, as well as the mixed water between them, turn northwestward at the south point of Greenland where they continue into Davis Strait; but the velocity and importance of the currents on their course along the western coast are diminished and they flow gradually westward out into the strait. The broad Labrador current can also be seen distinctly on the maps; it may often appear off the Hellefiske Banks. The current conditions in the middle of the Davis Strait are more complicated than has been supposed hitherto.

Plate VI and VII show the currents at 200 and 500 m depth computed with regard to the same reference level.

Cold water on the western coast of South Greenland.

Studying the hydrography of the waters of East Greenland we have seen that the drift of ice along this coast is subject to pronounced seasonal changes. Although we cannot reckon the extension of the ice as a limit of the polar current, as the ice naturally may be carried far beyond this limit by the wind, we may certainly reckon with a certain connection between the arrival of the ice at the different places at Southwest Greenland and the point of time when the more or less cooling effect of this cold current sets in.

Just as the ice along the eastern coast flows more quickly in summer than in winter, the polar current is most active off West Greenland later in summer.

According to SPEERSCHNEIDER (1931) the first Storis arrives at Cape Farewell in the last half of January; generally during February it fills up Julianehaabs Bay, reaching Arsuk in March, Fiskenæs in April and Godthaab in May or June, and its northward extension is greatest in May or June. The fact is, accordingly, that the Storis normally advances slowly along the western coast (2—4 nautical miles every 24 hours) but naturally this is only an average, on occasion it may deviate much from this, e. g. up to 15 nautical miles per 24 hours. The Storis reaches only as far as Fiskenæs in most cases, more seldom to Godthaab and but very rarely to Sukkertoppen. Twice during the last century is has reached even to Egedesminde.

We do not know how closely the arrival of the Storis off West Greenland coincides with the first activity of the polar current here, but the strength of the current is not at its highest till some time after the arrival of the ice. Although the current later in the winter ceases to flow more or less completely it is assuredly never at any season without influence upon the hydrography of the banks.

Off the southern fishbanks it is as difficult, as in Denmark Strait, to indicate definite values, characteristic of the water of the polar current. Concerning the greater part of Davis Strait we may say, however, that the current which, during the first part of the summer, is to be considered as a continuation of the East Greenland polar current must carry water at some depth (50—100 m) with a temperature near 0° C. or in any case lower than 2° C. and with salinities of 33.00—33.50 or at the highest 34.00 ‰. Close to the surface and the coast the deviations from this may be very great (see plate I, 1). During the summer the temperature rises often to 4° and the salinity is generally diminished. To lay down a few isotherms or isohalines as limits for the polar current would be of no practical use, as its characters vary so much from year to year. A judgement of the area must be carried out in each case, based on temperature, salinity, current and season. Here in Davis Strait, as off the eastern coast,

extensive eddies are formed between the polar current and the more salt water outside and below.

The hydrographic expeditions have never reached Greenland before May and we have therefore no sure knowledge of the hydrographic conditions in the first spring months. But in May and the beginning of June the polar current is always present off the southern part of the western coast, although it does not flow as fast, and appears not to be as broad, as later in the summer.

So far south as off Fiskenæs we are at this season (June 1st) generally north of the proper polar current and here, and further north, the conditions are everywhere like in winter and spring: very little movement in the water masses, and, although the temperature at the surface has risen perhaps to 1—2° C. or 3° C., we find at a slight depth over the southern banks i. e. Fiskenæs and Fyllas Banks rather stagnant water with a temperature about 0—1° and salinity of 33.50—34.00 ‰. A strongly cooled water layer such as we find further north does not appear, as the minimum temperature near the top of the banks, or a little deeper, is rarely lower than 0° C. (e. g. at Fyllas Bank $^{8}/_{6}$ 1908: ÷ 0.25° at a depth of 200 metres). On the contrary we find the temperature up to 2° C. in some years ($^{10}/_{6}$ 1936: 1.95° C. at a depth of 40 m). The most essential reason why the water has not cooled down so strongly is the fact that the winter is less cold but more windy than further north.

During the early summer the upper water layers are being slowly heated, partly on account of the suns radiation, partly due to influx of warmer water from the sides, and during June the negative temperatures have practically disappeared in the cold water layers round the tops of the banks.

In especially warm years the surface water may, as early as during June, reach a temperature of 4—5° C., and the water round the tops of the banks a temperature up to 2—3° C.

On its course along West Greenland the polar current is forced towards the coast by the deflecting power of the rotation of the earth; the faster the current flows, the stronger is the influence of this power, and the closer is the current pressed towards the banks.

In some years with a polar current of slight velocity it is able to leave the coast before it reaches the fish banks, and here temperature continues to rise fairly evenly during the summer.

But in years where the velocity of the polar current is near the normal, or stronger, the current is pressed by the rotation of the earth so strongly towards the outer slopes of the banks that it interferes with the heating of the water round the Fiskenæs Banks, Fyllas Bank and the south point of Lille Hellefiske Bank. The current attains its greatest cooling power at the end of June or sometime in July and in most years sometime about midsummer a more or less pronounced decline in temperature near the top of the banks can be found. In the most favourable cases a stop of the increase in temperature is observed, or there is a small decline (1889, 1924 and 1928 were years with temperature of about 2° (plate II, 2)), but in many cases an enormous water stratum with negative temperature (fig. 3 and plate II, 1) appears in the course of a few weeks.

As this advance of cold water off Fyllas Bank normally takes place at 50—150 m depth the surface temperature is less influenced by it. Here the increase of temperature generally continues throughout the summer, and, in warm years, it reaches from 6—9° C. in August and September. If the polar current does not spread itself over the top of the

bank, the increase of temperature from above may continue somewhat, even as far as this depth (50 m); but as the supply of warm water from below is stopped the temperature rises but slowly, and rarely more than 2° C. is found while the cold water lies outside. (fig. 4). The strong (i. e. the cold) advance of the polar current slows off usually before the middle of August and hereafter the warm water penetrates quickly both from above and below, so that 2—3° C. are reached at the top of the bank before the end of the summer. In years where the polar current is weak this temperature may be found as early as in June—July and after this the latter may rise further, up to 4—5° C. during the next months.

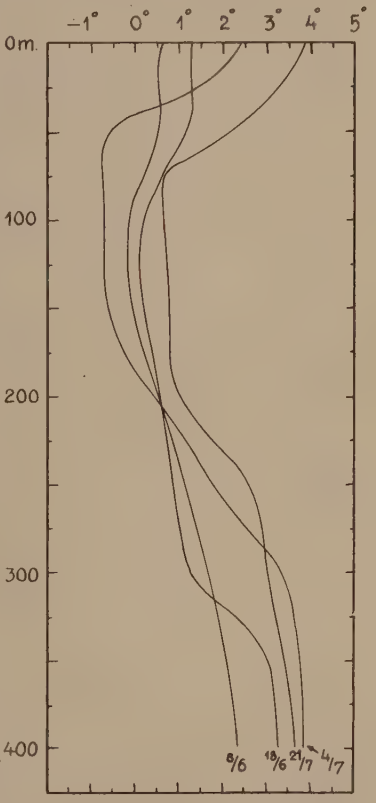


Fig. 3. Curves showing the temperatures off Fyllas Bank during the summer of 1925.

From autumn we have no observations in the polar current off the fish banks, but we know that further south, off Ivigtut and Julianehaab, it may flow with a considerable speed in September and October. It is then pressed close to the coast and a relatively small area only has a temperature of less than 2—3° C. (with salinity of less than 33.00 ‰). In especially warm years it may be heated up to about 4° off South Greenland (September 1928), while the temperature in cold years may stay near 1° C. (1908, 1909). Consequently it is reasonable so suppose that the current may also be found off Fiskenæs and Fyllas Banks, though possibly some way seawards, and in most cases it is not very cold.

The polar current is of no effect over the northern banks i. e. Helders Bank and Store Hellefiske Bank.

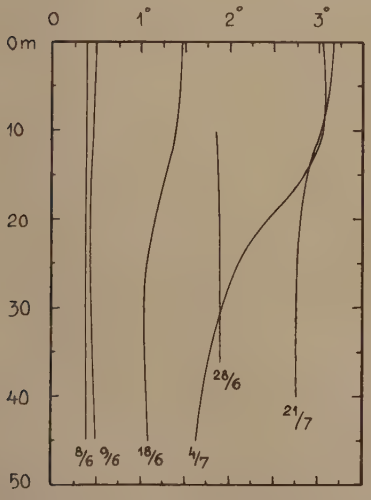


Fig. 4. Curves showing the temperatures above Fyllas Bank during the summer of 1925.

The explanation of the fact that the polar current is generally more prevailing in the middle of the summer on the banks off South Greenland is, we must suppose, that the current is weak early in the year and accordingly flows further out to sea, but during June the velocity increases so much that the current is pressed towards the coast and may thus wash the outer slopes of the banks. However, if the velocity of the current does not increase sufficiently, the current stays out at sea making one think that it has failed to appear that year.

The greater or smaller velocity of the polar current is therefore of essential importance for the summer temperature of the water round these southern banks; but besides this it is just as important whether its advance sets in early or late in the summer. For if it sets in early (June) there is plenty of time for warming up or mixing coming

both from above and below to bring about a suitable temperature at the top of the banks before the end of the summer. But if the cold advance does not set in till July or August there is not time enough for a later supply of heat, and the summer must on the whole be considered as cold.

While the Storis rarely reaches further northward than Godthaab because it gradually melts away, the polar current continues all the way along Fyllas Bank to Lille Hellefiske Bank in years when its speed is relatively great. Here it meets the projecting southern top of the bank and branches. Part of the current sometimes penetrates behind the bank and part of it continues northward along the outer side of the bank, but any greater water movement northward with the characteristic qualities of the polar current, cannot be found further north than the south point of Lille Hellefiske Bank. The irregularity of the bottom at greater depths off Fyllas Bank most certainly contributes to break up the current also. Over the deeper parts of Lille Hellefiske Bank and Helders Bank, and in the channels round them, cold water (0—1° C.), it is true, is in many cases present, in some years even very cold water ($^{26}/_{6}$ 1908: $\div 0.9°$, 33.71 ‰, $^{1}/_{7}$ 1925: $\div 1.33°$, 34.36 ‰) but this water does not originate from the polar current, among other reasons because it has a greater salinity than the water of the polar current off Fyllas Bank at the same time; this water has been cooled during the winter at the place, and stays till far into the summer.

Over Helders Bank and Store Hellefiske Bank we generally find a slow north going flow in the upper water strata; only a small part of the water originates from East Greenland, most of it is a local mixture of coastal water, winter cooled water and water of atlantic origin. Early in the summer the temperature is about 0° C., and the salinity is usually greater than that of the polar current (about 34 ‰) but by degress so much water is picked up from the land that in these areas the salinity declines to 33 ‰ while the temperature rises to 3—5° C. and, in the uppermost layers, even considerably higher.

The western ice over Store Hellefiske Bank spreads in winter generally so far eastward that it joins the coastal ice. This ice layer generally breaks up during May, but it may last till later on into June, and, in especially unfavourable years, it may stay over the western slope of the banks most of the summer. We must therefore, on arrival in these areas in early summer, expect to find cold water with negative temperature covering the whole bank. As soon as the ice has melted the warming up of the surface water rapidly accelerates, but close below the surface temperatures near 0° C. or even negative temperatures ($^{26}/_{6}$ 1925: $\div 1.38°$ C.) are normally found in early summer (June); apparently however, this cold water is not as stationary as is that over the great areas of Helders Bank. In case no ice at all has covered the bank during the spring the warming up is able to set in early, and the temperature of the uppermost 50 m of water may reach 4—6° C. if the following summer is warm (1924, 1928, 1936) while such temperatures in less warm years are found only in a quite thin surface layer.

The tidal currents are strong over Store Hellefiske Bank, but a uniform main current is but weakly developed. Accordingly, the upper water layers of this great shallow area are able to reach a temperature as high as, or even higher than, the temperature of the surface water over the more southern banks. Of course this warming up from the surface does not penetrate very deep and only the highest parts of the banks, with depths of 25—50 m reach up to this warm water of 4—5° C.

The greater part of the bank lies considerably deeper, partly about 100 m depth, and the warming up from the surface asserts itself only to a very slight degree at this depth.

Here, in many cases, the temperature stays at 1—2° C. during the summer (end of August 1908) and only in especially warm years it passes 2° C. appreciably solely as a result of heating from above, but when the atlantic current is strongly developed it may come to its help from below and wash the edge of the bank with water of 2—3° C. (1924, 1928).

The autumn sets in over Store Hellefiske Bank earlier than further south, and, as early as in the beginning of September, the temperature of the water declines, especially on the surface.

On the basis of the rather few and scattered observations available, the question as to what degree the water of the polar current penetrates into the channels between the banks is only settled with difficulty. We must also take into account that tidal currents with considerable velocity may rise in such channels. The difference between high and low tide is 2—3 m on the coast of Greenland and the current outside the banks is greatly effected by the tide; for instance it is a wellknown fact among the fishermen that the currents at the time of spring tide may become so strong as to cause them great difficulties.

The channel between Fyllas Bank and Lille Hellefiske Bank has been best investigated, but here especially we must expect to find strong currents, partly because Lille Hellefiske Bank protudes further to sea than Fyllas Bank so that the tide wave is caught in a funnel, and partly because this is the main entrance to the great and deep area lying behind the two banks. Most of the sections which can be drawn across the channel show a pronounced inward going current, especially in the higher water layers, where there is a constant cyclonic rotation round the southern point of Lille Hellefiske Bank. But observations from July the 5th 1925 show that on this day deep parts of the channel were filled up with colder water (÷ 0.6— ÷ 0.9° C.) and with higher salinity (34.00—34.20 ‰) than the water of the polar current off the bank at the same time, i. e. water which we must suppose has been cooled during the winter and has been lying somewhere behind the banks during the spring and which now, possibly due to tidal flows, entered the channel. Observations from other years (1909, 1924, 1928) apparently show that later in the summer atlantic water expels the cold bottom water and completely fills up the deep basin behind the banks.

The low temperatures which, in the first part of the summer, may appear in the channel between Helders Bank and Store Hellefiske Bank must also be considered as being of local origin.

Particulars regarding the velocity of the polar current off the western coast of Greenland will be dealt with in the chapter on the velocity of the warm under-current.

Besides the cold water from the East Greenland polar current and the water locally cooled in winter, we must take into consideration also the Canadian polar current. Normally it covers far more than the half of the northern entrance of Davis Strait, and, in the beginning of the summer, it often extends so far eastward, that, at a depth of 100—200 m, it washes the western slope of Store Hellefiske Bank with water at 0—1° C. with a salinity of about 34.00 ‰, or its somewhat higher layers (50—100 m) may spread over the deeper lying parts of the Bank and thus join the local cold water. While on the bank itself the latter water cooled in winter usually disappears during the summer, the deeper lying polar current water will often stay most of the year, preventing any influx of warm water from below.

Off Helders Bank too, the Canadian polar current in many cases occurs, but at any rate its effect here will certainly be quite transitory.

It is not always the polar current itself which washes the Greenland Banks, but a branch or eddy from it.

Warm water on the western coast of South Greenland.

As earlier stated the warm current passing Cape Farewell mostly consists of mixed water (polarfront water) and but little of unmixed Irminger water. It at once turns northwest and runs at some depth along the whole western coast of Greenland. South of about 66° N. Lat. the temperature reaches in most cases up to 3.5—4.5° C, and the salinity up to 34.75—35.00 ‰. Of course these values decline gradually further north, a decline which is greatest at the entrance to Baffin Bay — but as far as in the vicinity of the northern straits, the warm water can still be found.

Concerning the action of this current an annual period can distinctly be demonstrated, so that in the first part of the summer (June) an appreciable movement is found at the southern point of Greenland only, while north of this point water which has its origin in the Atlantic is rather stagnant, and is not found till a rather great depth. The current does not penetrate the whole length of Davis Strait till the end of the summer.

It has already been recorded how the current off Cape Farewell flows at a depth of 200—400 metres or somewhat deeper, and has, at the beginning of the summer, a temperature and salinity of 4—5° C and 34.75—35.00 ‰, and finally how its cross section comes to be triangular on account of the cold subarctic mixed water lying south and southeast of it. At the same time the warm water in Davis Strait itself lies on the outer slopes of the banks at a depth of 400—700 m and it flows, we must suppose, at the most, a few nautical miles every 24 hours. But out at sea the warm water rises nearer to the surface, and northwards the triangular section is rapidly effaced, because the cold mixed water occurs only in the southern part of the strait. As early as off Frederikshaab or Fiskenæs the warm current has broadened, and can be traced far out in the strait even at some depth (for instance 700 m) and here, beyond the polar current, the warm water reaches the surface, or nearly, both in spring and summer.

As the warm current during the summer sets in, it regularly approaches the coast and the border of the higher lying cold water rises along the outer slopes of the banks, reaching its highest off the southern banks, not so high northwards.

The following table illustrates this rise by help of average figures for the depth of the 3° isotherm off the different banks, the corresponding salinity is on an average about 34.50 ‰, a little less off Fyllas Bank a little higher off Store Hellefiske Bank respectively.

	Fyllas Bank	L. Hellefiske B.	St. Hellefiske B.
June	280 m	350 m	420 m
July	250 „	250 „	300 „
August	110 „	150 „	250 „

The differences from one year to another are very great; we must also expect to find considerable irregular waves along this border level. The mean figures show, however, a surprisingly even course of the rise, in spite of the scanty observations available, in all comprising only 30 sections, all from before 1930.

One remarkable fact appears at once viz. that the warm water off Fyllas Bank lies

only about 30 m higher in July than in June, while off the other banks during same interval a rise of 100—120 m has taken place. This clearly shows the activity of the polar current in the middle of the summer.

According to the table the warm water thus, on an average, stays at a depth greater than the top of the banks, and, setting aside the last ten years, warm water at 3° C. passing up over the top of the banks has only very rarely been demonstrated, while in all the comparatively warm years water with 2° C. passes over the edge of the southern banks and in several cases also the edge of Store Hellefiske Bank; when the warm water from below reaches so far as to get into contact with the warming up from above, there is the possibility of a strong and quick warming up of the strata round the tops of the banks. Accordingly we may measure here temperatures of 3—5° C. both over Store Hellefiske Bank and over the more southern banks.

How far on in the year this atlantic under-current continues to increase in temperature and vertical extension is not known with certainty, but from May till October the current normally increases steadily even off the most southern part of the coast, and when in years such as 1928 a strong current, with temperature and salinity of 5—7° C. and about 35.00 ‰ still occurs in October as far southward as off Ivigtut, the fact signifies that the warm current further north does not reach its maximum till sometime later in the autumn or in the beginning of the winter, whereupon it nearly ceases. Then the water is slowly cooled, reaching its minimum temperature and vertical extension early in the summer, before the effect of next year's warm current sets in. The warm water in the northern part of the Strait is, however, well protected against cooling by the lighter water above, and thus is able to keep a higher temperature than that of the water further south, and accordingly next spring (for instance May 1909) we find off Store Hellefiske Bank a temperature near 5° C. at a depth of about 400 m, and off the more southern banks a temperature of 4° C. but everywhere stagnant water. On account of such high temperatures early in the summer no deduction can be drawn as to the conditions later in the year.

Reaching its maximum sometime in the autumn, the current most probably washes the banks completely in most cases, and in this season is also able to force water in behind the banks and into the deep fjords, which the rest of the years are hidden behind thresholds. Its rate decreasing in autumn or in winter, the current probably retreats from the coast again and flows towards the deep water.

Along the outer side of the banks of West Greenland thus a struggle is fought between the cold water of the polar current and the warm atlantic under-current, a struggle which is most decisive as to whether the hydrographic conditions of the banks in different years turn out warm or not. Of either currents, however, the cold has beforehand the advantage of the warm, because it lies uppermost and innermost, and if it runs at a good rate and thus is pressed against the banks by the rotation of the earth, it is nearly impossible for the warm water to expel it. Accordingly we may judge almost solely from the energy of the polar current the possibility of a transgression of warm water over the banks; we are of course not informed whether the polar current itself or the coastal water are more or less strongly heated, and on this point the different years may vary very much. The year of 1928 was for instance a warm year, because the water everywhere was strongly heated; but at the same time the polar current was moving fast.

Velocity of the West Greenland current.

In this chapter particulars will be given of some calculations of the velocity of the current both at different distances from land i. e. in the polar current and in the atlantic current, and at different times of the summer.

In the diagram of fig. 5 from the year 1928 the deeper of the dotted curves denotes the current velocity about 50 nautical miles southwest of Cape Farewell (on May 29th) i. e. in the middle of the warm current. At this season there is only a comparatively slight velocity (not counting the uppermost 100 m) but in the autumn (as shown by the curve drawn as a continuous line) about 40 nautical miles off Ivigtut a velocity of 34—36 cm sec $^{-1}$ (about 17 nautical miles every 24 hours) penetrating to rather great depths. Of the rest of the curves the dotted refer to the conditions off Cape Farewell in the month of May as well, and the unbroken lines to the conditions off Ivigtut in the month of October, and all of them are covering the banks so far that they wholely or partly represent the polar current. According to their distance from the coast they correspond two by two, i. e. stations 3 and 186 and stations 4 and 185 lie in couples at about the same distance from the coast. It is evident that the polar current is well in action off Cape Farewell immediately at the beginning of the summer, it increases however considerably during the summer and its velocity so late as in October is still greater than in May.

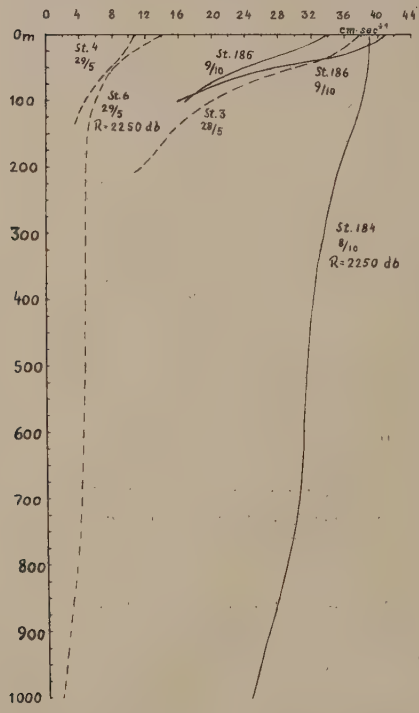


Fig. 5. Current velocity off Cape Farewell May 1928 and off Ivigtut October 1928. See text.

In the year 1928 the velocity of both the warm and cold currents was considerably increased without causing any marked change in their mutual balance. Although such a pronounced increase of velocity cannot be expected in all years, the figure clearly illustrates, I am sure, the general rule that the northgoing water, especially off the banks, is slow early in the summer but increases later on, both over the banks itself and beyond.

In fig. 6 the curve dated $^{10}/_{7}$ 1889 gives an instance of how the polar current off Fyllas Bank has completely ceased, thus allowing the warm under-current — although this was very weak — to dominate without difficulty, and this is in accordance with the fact that 1889 was one of the warmest years. The curve of $^{20}/_{6}$ 1925 shows, on the contrary, a very strong motion in the upper volumes of water off Lille Hellefiske Bank corresponding to the fact that the polar current that summer has made an especially strong advance.

The difference in current velocity between the upper and lower water layers is generally not as great as it was in 1925, but, in most cases, the current curves off the banks bear an analogy to the latter as, for instance on $^{2}/_{8}$ 1928.

The estimation of the importance of the currents for the banks is complicated by the

fact that the warm under-current does not always run equally close to all the banks, even if it flows at a good speed. Instances derived from the observations show how it may reach far up along Fyllas Bank and Store Hellefiske Bank, while it may, as it were, swerve somewhat from Lille Hellefiske Bank, and conversely the latter may be the bank most favoured. Such irregularities are no doubt due to the bottom relief out in the strait and in fact it is just off Fyllas Bank and Lille Hellefiske Bank that we find the first deep-lying banks.

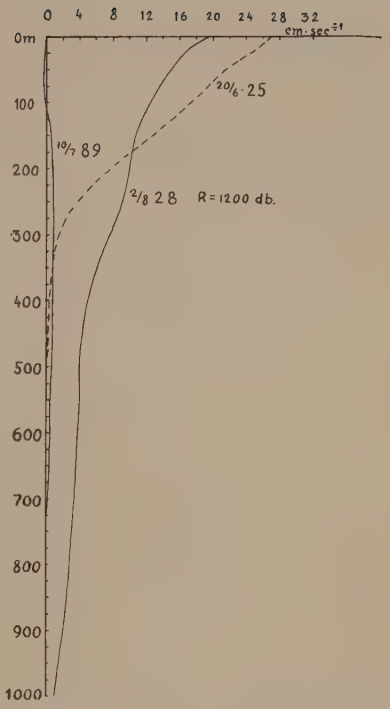


Fig. 6. Current velocity off Fyllas Bank 1889 and 1928, and off Lille Hellefiske Bank 1925. See text p. 20.

Water transport of the currents.

The increase of activity of the currents during the summer can be illustrated not only by drawing current curves, but also directly by computing the water transport of the currents for a unit of time[1]). Such a computation, it is true, is based on the same figures as is computation of the current velocities, and nor can we in this way so easily investigate in detail the different parts of the currents, but in return we attain in broad outline a very illustrative picture. On the basis of the observations of the "Godthaab" expedition in the summer of 1928 the following values are computed for the whole water transport northward at the beginning of the summer and at its end.

1st June SW. of Cape Farewell it carries	200	cubic	kilometres	per	24 hours
9th October SW. of Ivigtut „ „	400	„	„	„	24 „
1st July SW. of Holsteinsborg „ „	30	„	„	„	24 „
17th September SW. of Holsteinsborg it carries	90	„	„	„	24 „

Off Ivigtut the current, as a matter of fact, conveys 1530 cubic kilometres per 24 hours flowing northward in October, but at the same time on the western side of the oblong eddy which appears in the current maps off the southern part of the coast, the current carries 1125 cubic kilometres per 24 hours southward, and as the latter mostly has its origin in the West Greenland current it ought to be deducted from the 1530 cubic kilometres although a too low figure possibly is obtained in this way. Thus corrected these computations show that both off Cape Farewell and at the entrance of Baffin Bay the water transport increases at least by two to three times during the summer.

The fact still remains to be mentioned that we must take into account vertical currents inside Davis Strait. Chemical analysis (contents of oxygen or salt) or investigations on the content of plankton are, generally, the best way to find out such motions, but here by help of dynamic computations we are able to demonstrate the presence of such motions

[1]) Regarding the methods ref. A. Kiilerich 1939.

inside the strait, for we possess some knowledge of the annual variations of the most important currents as well as of the whole water economy of the strait.

In the vicinity of the banks the polar current reaches a greater depth the greater the velocity it has compared to the velocity of the warm under-current (i. e. during short periods in the middle of the summer). — Conversely the lower lying water rises if the polar current decreases in velocity and retreats from the banks, this, most certainly, often happens during the greater part of the summer and may cause vertical movements which, we must suppose, cover several hundred metres and they may thus be of importance for the organic life such as fish fry.

Investigation of the water economy of the whole strait shows that in the depths more water enters the strait from the Atlantic than flows out of it, while there is a great surplus of water moving southward in the upper layers. This goes to prove that in some places in the strait very far-reaching ascending water motions occur, probably in the cyclonic eddies.

3. Hydrography of Disko and Baffin Bays.

The submarine ridge running from Store Hellefiske Bank to Cumberland divides very effectively the volumes of water of Davis Strait and Baffin Bay. The temperature, and to some extent the salinity, is remarkably reduced when passing the ridge; a strong eddy formation exists, and the border line between the Canadian polar current and the West Greenland current undulates considerably, though always lying nearest to Greenland.

The northgoing current of the upper water layers off the western coast of Greenland, the greater part of which keeps over Store Hellefiske Bank is so slow that its supply of water to the more northern areas is only of slight importance.

The effect of the warm under-current running along the outer slope of the bank is far greater; most years its temperature reaches up to 3—4.5° C. and its salinity up to 34.50—34.80 ‰ at the northern part of the strait. The core of the current lies at 300—500 metres depth, and in the early summer the upper limit lies at 200—300 metres, gradually rising along the outer side of the bank up to 100—200 metres. Downwards the warm current may sometimes reach the bottom, but as a rule cold water from the depths of Baffin Bay wedges in under it, and is even able, at a depth of 500—700 metres, to force part of the current away from the slope of the bank occupying this space itself, and branches of the atlantic current then occur in the middle of the strait.

Disko Bay receives very little water from the south in the early summer. The deeper water layers hardly move in this season, and the weak current of the upper water layers runs across the mouth from south to north. Inside the bay a weak cyclonal current is found moving inwards along the southern side of the bay and outward along the whole of the northern side, but towards the end of the summer a rather strong inward moving current covers nearly the whole bay and apparently the Vaigat functions as outlet.

In June and the first half of July we find in the Disko Bay, under a warm surface layer (6—9° C.) a cold water layer at 50—150 metres depth with negative temperature, the latter is connected with the corresponding cold water in Baffin Bay, while cold water from the Jacobshavn glacier cannot be traced very far. During the month of July the negative temperature quite disappears, and at the beginning of September the warming up from the surface can be traced as far as to about 200 m depth.

In the deeper parts of the bay (as far as to 750 m) a temperature and salinity of 1—2.5° C. and 34.10—34.65 ‰ appears, but no increase in the temperature during the summer has been demonstrated. The renewal of waters at these depths is very defective, and takes place, we must suppose, sometime late in the autumn or even in the winter. This also corresponds well with the fact that stronger or weaker atlantic characters in the deeper lying parts of the bay do not set in simultanously with stronger or weaker action of the warm under-current in Davis Strait. The character of these water layers may perhaps depend on the conditions of the warm under-current in the preceding year.

Having passed Store Hellefiske Bank later in the summer, a part of the upper water layer of the West Greenland current enters Disko Bay, but most of it by far continues north across the Disko plateau but at a low rate. The temperature may also here rise to about 5° C. (salinities 33—34 ‰) at the surface, but as early as at about 50 m depth the winter cooled water of Baffin Bay with its negative temperature appears. On its course to the northern part of the Bay the temperature at the surface may still reach 4 or 5° C., due to the supply of heat from above. In spite of several eddies the current follows rather close to the western coast of Greenland, and can be traced through Smith Sound as far as Cape Alexander.

Also the warm under-current sends the main part of its water into Baffin Bay, where it keeps at 400—500 m, following the outer slopes of the banks. The temperature decreases towards the north and is about 2.5° C. at the southern point of the Disko plateau, about 2° C. west of Disko, about 1° in the northern part of the bay. The last off-shoot of the current is perceptible at 500—800 m depth at the inlet of Lancaster Sound, where the temperature is 0.—0.5° C., while the branch running along the eastern side of Smith Sound is very weak and not warmer than ÷ 0.5° C.

Between the surface water and the warm under-current lies a water layer 200—300 m thick, of which temperature is constantly negative (÷ 1.5—÷ 1.7° C.).

The warm water occurring in the summer at the intermediate depths in the northern part of Baffin Bay cannot possibly come from water which crossed the ridge the same year. It at least comes from water which flowed into the bay the previous year — though possibly late in the autumn — and which perhaps itself passed Cape Farewell the year before. Consequently we cannot expect to find a conformity between the deviations in the temperatures here and the simultaneous deviations in Davis Strait, the most natural thing would be for such variations of the two sea areas to succeed at intervals of 1 to 2 years.

III. The hydrographic conditions of West Greenland in different years.

Comparison of the hydrographic conditions at West Greenland in different years with the above survey makes it possible for a great number of years to obtain information to what degree and at which points individual years deviate from the average.

The results of such a comparison have here been summed up partly in tables and partly in a short text. As it has, however, been impossible, by the help of a few values to characterize a single year we must put up several columns in the tables and fill these in, as far as sufficient observations are available from the year and area concerned. As far as possible here is noted the deviations from the average which can be demonstrated, and also some of the main results of the observations.

Year. Weather conditions. Ice conditions. Surface temperature.	Cape Farewell — Fiskenæs Banks	Fyllas Bank	Lille Hellefiske Bank
1883. Summer cool and wet. Much Storis in Davis Strait. Surface temp. below the normal in Davis Strait and Baffin Bay.	Polar current broader and colder than normal. June: + 0.6°; 33.17 ‰. Aug.: 0°; 33.62 ‰. Atlantic under-current: not demonstrated.		Winter cooled water at the top of the bank: temp. nearly normal. June: 0.2°; 33.64 ‰.
1884. Winter and summer: temp. of air: below the normal. Much Storis in Davis Strait. Western ice found very easterly. Surface temp.: 1 -3° below the normal.	The width of the polar current in June at the highest normal (less than 40 naut. miles). Atlantic under-current: well represented even up to the surface at 40 naut. miles from land. June: 3.8°; 34.76 ‰.	Over the bank temp. a little above normal. July 1st: 1.9°; 33.60 ‰. Polar current: a little way out at sea, slow. Temp. normal. July 1st: 0°; 33.82 ‰. Atlantic under-current: did not occur close to the bank. The warmest water: July 1st: 3.5°; 34.25 ‰.	Winter cooled water stagnant over the bank. Temp. normal. July 8th: 0.6—1.0°; 33.75 ‰. Cold water on the outer side of the bank, possibly winter cooled water. Temp. abt. normal. July 8th: 0°; 34.50 ‰. Canadian polar current: far out at sea. July 8th: + 0,5°; 34.25 ‰. Atlantic under-current: greater vertical extension and warmer than normal and with good speed. July 8th: 4°; 34.75 ‰.
1886. Winter and summer: temp. of air: a little below normal. Storis and western ice: greatly extended. Surface temp. above normal.		Winter cooled water on the outer side of the bank warmer than normal. July 16th: abt. 2°; 34.25—34.50 ‰. Polar current: not present on the 16th of June. Atlantic under-current: great vertical extension especially out at sea. Temp. and salinity: a little above the normal only. June 16th about 4°; 35.00 ‰.	

Helders Bank	Store Helleflske Bank	Disko Bay	Baffin Bay	Summary
			Cold water layer: normal temp. July: + 1.0—+ 1.7°.	Cold: exceptional extension of the polar current.
			Atlantic under-current: probably rather warm. July: 0.4—1.2°; 34.45 ‰	
	Winter cooled water over the bank. Temp. normal early in the summer, but rise of temp. slow. July 9th: 1°; 34.50 ‰.	Surface: a little warmer than normal.		Warm water off Lille Helleflske Bank. Otherwise normal or colder.
	Cold water on the outer side of the bank, possibly polar current, delays supply of heat from below. July 9th: 0°; 34.35 ‰.	Cold intermediate layer: temp. normal. July 25th: + 0.5°; 33.80—33.90 ‰.		
	Atlantic under-current: vertical extension a little greater than normal. Temp. normal. July 9th: 4.0°; ? ‰. later some rise.	Deep water layers: extraordinarily great supply of atlantic water. July 25th: 2.7°; 34.85 ‰.		
				Warm, all water masses warm.
	Canadian polar current: rather close to the northern side of the bank. July 29th: + 1.7°; 34.00 ‰. Atlantic under-current: at the northern side of the bank warmer than normal. July 29th: 3.0°; ? ‰.			

Year. Weather conditions. Ice conditions. Surface temperature.	Cape Farewell—Fiskenæs Banks	Fyllas Bank	Lille Hellefiske Bank
1889. Winter and summer: temp. of air: normal. Storis and western ice: abnormally great extension. Surface temp.: generally below the normal.		Over the bank: temp. a little above the normal. July 16th: 2.7°; 33.50 ‰. Polar current, weak, warm and far out at sea. July 10th: 2°; 34.00 ‰. Aug. 3rd: 1.9°; ? ‰. Atlantic under-current: warm, slow with abnormal vertical extension. July 10th: 4,5—5,0°; 35.00 ‰.	
1895. Winter: stormy, mild and rainy. Summer: at the beginning normal, at the end with much sunshine, dry. Only a little Storis. Western ice: very easterly, covering Store Hellefiske Bank. Surface temp. south of Godthaab up to 3° C. above the normal, north of it up to 1,8° C. below the normal.	Remains of polar current 100—200 naut. miles from land, weak. Juni 20—22nd: 0.8°; 34.74 ‰. July 28—29th: 8.5—10°; < 33.75 ‰. Atlantic under-current: pronounced at 100—200 naut. miles from land. Temp. normal. June 20—22nd: 3.0—4.5°; 34.85—34.93 ‰. July 28—29th: 4.0—4.5°; 34.85—34.97 ‰.	Winter cooled water at the top of the bank, a little colder than normal. June 26th: 0,6°; 33.00 ‰. Polar current, weak and very broad. Temp normal. June 26th: 0.1°; 33.25 ‰. Atlantic under-current: with great vertical extension. Temp. rather high. June 26th: 4.0°; 34.75 ‰.	
1908. Winter and summer: temp. of air: normal. Much Storis in early summer. Surface temp. south of Holsteinsborg below the normal, north of it above.	Polar current very pronouced over the banks at the end of summer. Sept. 23—24th: 1.2°; 31.32‰. Atlantic under-current: towards the end of summer with great vertical extension and rather warm. Sept. 23—24th: 5—6.2°; 34.50—35.00 ‰.	Cold water on the top of the bank, colder than normal. June 9th: 0,05°; 33.37 ‰. June 22nd: 0.3°; abt. 33.30 ‰. Polar current, slow and broad. Temp. low. June 8th: ÷ 0.7°; 33.37 ‰. Atlantic under-current: weakly represented and deep-lying. June 8th: 3.5°; 34.80 ‰.	Winter cooled water on the top of the bank; temp. low and slowly rising. June 26th: ÷ 0.9°; 33.70 ‰. Aug. 28th: 0—1°; 33.60 ‰. Atlantic under-current: not demonstrated.

Helders Bank	Store Hellefiske Bank	Disko Bay	Baffin Bay	Summary
inter cooled water: over the bank: Temp. above the normal. July 21st: 0.3°; 35.00 ‰. anadian polar current far off the slope of the bank. tlantic under-current: great vertical extension, warm but slow. July 22nd: 4.5°; 35.00 ‰.	At the top of the bank: temp. below normal. July 26th: 2.6°; 33.86 ‰. Canadian polar current: very broad, washes the bank. July 26th: 1°; 34.25 ‰. Atlantic under-current: temp. and salinity above the normal, but forced deep down. July 26th: 4.0—4.4°; 35.00 ‰.			Especially warm: weak polar current, much atlantic water.
inter cooled water at the top of the bank: temp. about normal. July 1—18th: 0.2—0.3°; about 33.50 ‰. anadian polar current: far out at sea. lantic under-current: rather warm, but forced deep down along the side of the bank. July 1—18th: 4,3°; about 34.50 ‰.	Winter cooled water on the top of the bank: temp. normal or a little above. July 11th: 1°; 33.30 ‰. Canadian polar current: a little way out at sea. Atlantic under-current: higher up than normal. Temp. normal or a little above. July 11th: 3.9°; 34.70 ‰.			Warm: weak polar current, much atlantic water.
ke Lille Hellefiske Bank.	Winter cooled water: cold over the bank. July 3rd: 0.2°; 33.60—33.70 ‰. Aug. 23rd: 1.45°; 33.50 ‰. Polar current close off the bank, partly connected with winter water. Atlantic under-current: flowing at a good rate, rising a little along the bank. Temp. a little below the normal. July 6th: 3—3.4°; 34.50—34.65 ‰. Aug. 21st: 3.24°; 34.69 ‰.	Deep water layers: with very little influx of Atlantic water. July: 1.0°; 34.10 ‰.	Umanak Fjord. Cold intermediate layer possibly colder than normal. Aug.: ÷ 1°. Deep water layers: temp. normal or a little below. Aug.: 1°; 34.50 ‰.	Very cold, cold water everywhere.

Year. Weather conditions. Ice conditions. Surface temperature.	Cape Farewell— Fiskenæs Banks	Fyllas Bank	Lille Hellefiske Bank
1909.			
Winter and summer: temp. of air: normal.		Winter cooled water over the top of the bank somewhat colder than normal. June 9th: 0.5—0.7°.	
Storis early summer very great extension, later only small.	Polar current weak and ramified in early summer, strong but narrow later in the summer. Temp. low. Sept. 25th: 1°; 33.00 ‰.	Polar current not demonstrated in May—June.	
Surface temp. early summer normal, later unknown.	Atlantic under-current: early summer: great vertical extension temp. normal. Later in the summer: possibly normal vert. extension and temperature. May 1st: 4°; 34.90—34.95 ‰. Sept. 25th: 5.5—6.0; 34.75—35.00 ‰.	Atlantic under-current great vertical extension early summer. Temp. above normal. May 7th: > 4°; abt. 34.90 ‰.	
1916.			
Winter and summer: temp. of air: very much above the normal.			
Extraordinarily little ice in Davis Strait and much in Baffin Bay.			
Surface temp. in Davis Strait above the normal, in Baffin Bay below.			

Helders Bank	Store Hellefiske Bank	Disko Bay	Baffin Bay	Summary
inter cooled water: at the top of the bank, stagnant, temp. below the normal. May 11—15th: ÷ 0.1—÷ 0,5°; 33.70—33.90 ‰.	Winter cooled water over the bank: stangnant. Temp. normal. May 22nd: 0.1—0.5°; 33.85—33.95 ‰.			Some possibility for a warm year.
	Canadian polar current: close off the bank. Full rate southward.			
lantic under-current: early summer. Great vert. extension and very warm but stagnant. May 12th: 4,79°; 34.87 ‰	Atlantic under-current: early summer. Extremely great vertical extension, warm but stagnant. May 20th: 4.8°; 34.80—34.90 ‰.			
		Surface temp. normal. July 2—6th: 4.5—5.7°; about 32.50 ‰. July 22nd: 7.7°; 32.50 ‰.	Surface temp. very low.	
		Cold intermediate layers colder than normal. July 22nd: ÷ 0,7°; 33.60 ‰.	Cold intermediate layer: possibly colder and thicker than normal.	
		Deep water layers: very little Atlantic supply. July 2nd: 0.65°; 34.18 ‰. July 22nd: 0.75°; 34.18 ‰.	Atlantic under-current normal temp.: Aug. 12th: 1.06°; 34.51 ‰.	

Year. Weather conditions. Ice conditions. Surface temperature.	Cape Farewell—Fiskenæs Banks	Fyllas Bank	Lille Hellefiske Bank
1924. Winter and summer: temp. of air over the normal. Much Storis in April—Juni, later just normal. In the northern part of Baffin Bay only very little ice. Surface temp. much above the normal, except close to the coast where it is below the normal.		Polar current, strong advance in July. At the top of the bank: June 24th: 2.5°; 33.00 ‰. July 5th: 2.2°; 32.90 ‰. Aug. 4th: 1.8°; 32.91 ‰.	Over the bank: temp. normal. Aug. 6—7th: 2—2.5°; 33.20—33.40 ‰. Canadian polar current(?) on the outer side of the bank far to the east. Aug. 7th: ÷ 0.44°; 33.78 ‰.
		Atlantic under-current: strong and warm, high up along the bank. Aug. 18th: 5°; 34.80 ‰.	Atlantic under-current: normal extension and temperature. Aug. 7th: > 3,9°; > 34.70 ‰.
1925. Winter and summer: temp. of air below the normal. Much ice off Julianehaab in early summer, otherwise below the normal. Surface temp. normal on an average.	Winter cooled water over Fiskenæs Bank, a little colder than normal. June 7th: ÷ 0.02°; 33.58 ‰.	Winter cooled water over the top of the bank. In June normal temp. in July too slow warming up. June 8th: 0.4°; 33.70 ‰. » 18th: 1°; 33.80 ‰. July 4th: 1.7°; 33.60 ‰. » 21st: 2.75°; 33.20 ‰.	Winter cooled water at the top of the bank cold and very constant. June 20th: 0.2—0.5°; 34.00 ‰. July 3rd: 0°; 34.00 ‰. very cold water over deeper parts of the bank. July 4th: ÷ 1.0—÷ 1.3°; 34.00—34.35 ‰.
	Polar current: in June weak and thin, but very broad. Temp. rather higher than normal. In the beginning of July strong advance but narrow. June 5— 6th: 0.3—1.55°; 33.45—33.60 ‰. July 7— 8th: ÷ 0.6°; 33.60 ‰. July 9—10th: 0°; 33.50 ‰. July 23rd: 0.87°; 31.98 ‰.	Polar current (in June possibly winter cooled water) in June very weak, but somewhat colder than normal. In July extraordinarily strong advance, very cold. June 8th: ÷ 0.2°; 33.80 ‰. » 18th: abt. 0°; 33.85 ‰. July 4th: ÷ 0.65°; 33.90 ‰. » 21st: 0.65°; 34.80 ‰.	Polar current: not present.
	Atlantic under-current: normal vertical extension and temp. June 6— 7th: abt. 4°; 34.95—35.00 ‰. July 7—10th: 4—4.5°; 34.97 ‰.	Atlantic under-current: colder and weaker than normal. June 8th: 3.8°; 34.96 ‰. » 18th: 3.9°; 35.05 ‰. July 4th: 3.8°; 34.92 ‰. » 21st: 3.9°; 34.92 ‰.	Atlantic under-current: colder than normal but with great energy and about July 1st good advance up along the bank. June 20th: 3.9°; 34.92 ‰. July 4th: 3.2—3.7°; 34.80—34.90 ‰.

Helders Bank	Store Hellefiske Bank	Disko Bay	Baffin Bay	Summary
	Winter cooled water: warm over the top of the bank. July 9th: 2.7°; 33.50 ‰. Aug. 8th: 4.3°; 33.03 ‰. Canadian polar current: tongue passing far in over the southern part of the bank: Aug. 8th: 1—÷1.5°; 33.50—33.70 ‰. Atlantic under-current: warm and very high up along the bank. Aug. 8th: 4°; 34.80 ‰.	Upper water layers: normal. Deep water layers: strong supply of Atlantic water. Aug. 15th: 2.42°; 34.75 ‰.		Warm, but a pronounced advance of the polar current in the middle of the summer.
	Winter cooled water: nearly everywhere over the bank cold but stationary. June 22—30th: ÷0.2—÷1.5°; 34.00—34.25 ‰. Atlantic under-current: a little way out at sea, temp. and salinity below the normal. June 22nd: >3.1°; >34.75 ‰. » 26th: >3.1°; >34.70 ‰.	Cold intermediate layer: temp. about normal. June 29th: ÷0.5°; 34.00 ‰. Deep water layers: Supply of atlantic water strong. June 29th: 2.5°; 34.65 ‰.	Cold intermediate layer: colder than normal in Baffin Bay, but warmer in Smith Sound.	Very cold, and strong advance of the polar current in July.

Year. Weather conditions. Ice conditions. Surface temperature.	Cape Farewell—Fiskenæs Banks	Fyllas Bank	Lille Hellefiske Bank
1926. Winter and summer: temp. of air: above the normal. Only a little ice. Surface temp. generally considerably above the normal.		The temp. of the upper water layers much above the normal during the whole summer. Great supply of heat from above. Surface: June 14th: 2,3°; 33.90 ‰. July 27—30th: 4—5°; 32—33 ‰. Sept. 7th: 4.35°; 31.65 ‰. Polar current: advance in July, but not very cold. July 28th: 1.9°; 33.50 ‰.	
1928. Winter and summer: temp. of air: above the normal. Less ice than normal in Davis Strait and Baffin Bay. Surface temp. above the normal.		Upper water layers: early and strong heating, continues during the summer. June 18th: 1.8°; 33.40 ‰. Aug. 1st: 3.0°; 33.00 ‰.	Over the bank: only very warm water. Oct. 2nd: 3.8—4.8°; 32.20—33.00 ‰.
	Polar current, the whole summer narrower and warmer than normal. May—June: ÷ 0.6—÷ 1.6°; 32.50—33.50 ‰. Aug.—Oct.: 2,4—4.0°; 32.00—33.00 ‰.	Polar current: much warmer than normal. June 19th: slow 0.75°; 33.40 ‰. Aug. 2nd: quick 2.4—2.7° 33.50—34.00 ‰. Decrease in temp. in the middle of the summer, but still above the normal.	Polar current not present.
	Atlantic under-current: very great vertical extension, and much warmer than normal during the summer rate increases strongly. May—June: 4.5—5.0°; 34.95—35.00 ‰. Aug.—Oct.: 5.0—8.0°; 34.80—3507 ‰.	Atlantic under-current: very great vertical extension and much warmer than normal. June 19th: 4.4°; 34.92 ‰. Aug. 2nd: 5.0°; 34.92 ‰.	Atlantic under-current: passes the edge of the bank, temp. above the normal. Oct. 3rd: 3.5—5.0°; 33.00—34.30 ‰.

Helders Bank	Store Hellefiske Bank	Disko Bay	Baffin Bay	Summary
inter cooled water: expelled from the inner side of the bank before October. Oct. 3rd: 3.5°; 32.50 ‰.	Upper water layers: strongly heated. Surface: Aug. 16th: 5.7°; abt. 34.00 ‰. At the top of the bank: Aug. 16th: 4.8°; abt. 34.00 ‰.			Possibly warm.
	Upper water layers: early and strong heating. July 2nd: 2.5°; 34.00 ‰. Sept. 20th: 5.3°; 32.30 ‰. Winter cooled water: over the edge of the bank warmer than normal. July 2nd: 1.95°; 34.10 ‰. Aug. 4th: 1.5—2.0°; 34.00 ‰. Sept. 20th: 3.0°; 33.60—33.80 ‰. Canadian polar current: far outside the bank temp. normal. (÷ 1.7°).	Surface water: somewhat warmer than normal. July—Aug.: 8—9°; 32.00—33.00 ‰. Sept.: 5.0—6.7°; 32.50—33.00 ‰. Cold intermediate layer: warmer than normal, hardly any negative temp.	Surface water: warmer than normal. Aug. 23rd: abt. 5°; 31.00—32.00 ‰. Cold intermediate layer: probably normal. Aug. 23rd: ÷ 1.7°; 33.70 ‰.	Very warm, all water masses warm.
	Atlantic under-current: warmer than normal; during the summer up to the edge of the bank at 100 m depth. July 3rd: 3.6°; 34.75 ‰. Aug. 4th: 4.0°; 34.75 ‰. Sept 20th: 3.5°; 34.70 ‰.	Deep water layers: less atlantic admixture than normal. Sept. 9th: 1.56°; 34.29 ‰.	Warm under-current: probably normal. Aug. 23rd: about 1°; 34.40—34.49 ‰.	

Year. Weather conditions. Ice conditions. Surface temperature.	Cape Farewell— Fiskenæs Banks	Fyllas Bank	Lille Hellefiske Bank
1931. Winter and summer: temp. of air: above the normal. Less ice than normal. Surface temp. above the normal.	Polar current off Cape Farewell very narrow. Temp. normal. Aug. 1st: 0.21°; 32.38 ‰. Off Ivigtut broad and strong. Temp. normal. July 28th: ÷ 0.27°; 32.74 ‰. Atlantic under-current: temp. and vertical extension very much above the normal, especially off Cape Farewell. July 28th: 5.0—6.5°; 35.00 ‰.		
1933. Winter and summer: temp. of air: above the normal. Less ice than normal. Surface temp. above the normal.	Polar current off Cape Farewell very weakly represented, warm. July 9th: 2.02°; 33.31 ‰, Off Ivigtut broad and strong. Temp. normal. July 14th: ÷ 0.1°; 33.30 ‰. Atlantic under-current: temp. and vertical extension much above the normal. July 4.5—5.5°; > 35.00 ‰		
1934. Winter: temp. of air: normal. Summer: temp. of air: above the normal. Only a little Storis, but some western ice off Store Hellefiske Bank and Disko. Surface temp. much above the normal.		At the top of the bank: warmer than normal. June 22nd: 2.7°; 33.80 ‰. Aug. 16th: 3.2°; 32.95 ‰. Polar current: not present. Atlantic under-current: extraordinarily great vert. extension and warm — in Aug. even up to the edge of the bank. June 22nd: 4.6°; 34.95 ‰. Aug. 16th: 5.0—5.6°; 34.25—35.00‰.	Upper water layers, very warm. June 28th: abt. 5°; 33.00 ‰. Winter cooled water: at the top of the bank somewhat warmer than normal. June 28th: 1.0—1.4°; 33.80—33.90 ‰. Polar current: not present. Atlantic under-current: great vert. extension, and somewhat warmer than normal. June 28th: 4.3°; 34.90—34.95 ‰.

Helders Bank	Store Hellefiske Bank	Disko Bay	Baffin Bay	Summary
				Probably warm.
				Probably warm.
				Extraordinarily warm. All water masses warm.

Year. Weather conditions. Ice conditions. Surface temperature.	Cape Farewell— Fiskenæs Banks	Fyllas Bank	Lille Hellefiske Bank
1936. Winter and summer: temp. of air: above the normal. Less ice than normal. Surface temp. above the normal.		At the top of the bank: warmer than normal. June 10th: 1.95°; 33.58 ‰. Aug. 31st: 2.93°; 32.95 ‰. No polar current of importance. Atlantic under-current: extraordinarily warm and great vertical extension, exceptionally strong advance during the summer. June 10th: 4.35°; 34.89 ‰. Aug. 31st: 5.00—5.75°; 34.97 ‰.	
1937. Winter and summer: temp. of air: below the normal. Extension of ice normal or a little below the normal. Surface temp. normal or somewhat higher.	Polar current less than 60 naut. miles broad off Ivigtut.	At the top of the bank: somewhat warmer than normal. June 2nd: 1.3°; 34.00 ‰. Aug. 30th: 3.4°; 33.00 ‰. The advance of the polar current strong but not cold. Aug. 30th: 2.5—3.0°; 33.50 ‰. Atlantic under-current deep lying, but temp. somewhat above the normal. June 2nd: 600 m 4.34°; 34.90 ‰. Aug. 30th: 400 m 5.04°; 34.96 ‰.	Over the bank: temp. normal. June 3rd: 1°; 34.30 ‰. Aug. 29th: 2.5°; 33.80 ‰.
1938. Winter and summer: temp. of air: below the normal. More ice than normal. Surface temp. very low over the bank.		Over the bank: temp. below the normal. June 1st: ÷ 0.04°. The cooling effect of the polar current strong and continuous. Aug. 23rd: 0.94°. Atlantic under-current: cold and extraordinarily deep lying. June 1st: at 600 m 3.40°. Aug. 23rd: at 250 m 3.00°. » » at 500 m 4.58°.	Over the bank: temp. below the normal. June 2nd: ÷ 0.68°.

Helders Bank	Store Hellefiske Bank	Disko Bay	Baffin Bay	Summary
Winter cooled water over the bank somewhat warmer than normal. June 11th: abt. 1°; 33.75 ‰. Aug. 31st: » 2.5°; 33.75 ‰.	Over the bank: warm and strong warming up. June 11th: 1.50°; 33.90 ‰. Aug. 30th: 5.20°; 33.00 ‰. Cold water on the outer slope. abt. normal temp. Aug. 30th: 2.35°; 34.00 ‰. Atlantic under-current: warmer than normal. Aug. 30th: 4.10°; 34.80 ‰.			Extraordinarily warm. Nearly as in 1934.
	Over the bank: early summer normal temp. later rather strong warming up from above. June 4th: 0.7°; 34.20 ‰. Aug. 28th: 4.7°; 34.60 ‰.			A little warmer than normal in the upper water layers.
	Over the bank: temp. below the normal. June 4th: ÷ 0.6°.			Extraordinarily cold. All water masses cold.

1875. The early summer as regards the Davis Strait seems to have been dominated by the rather great extension of the Storis and low surface temperature near Greenland, while possibly some atlantic water was to be found out at sea. Later in the summer there was still much atlantic water out in the strait; but we have no information, if it has reached the coastal banks too. In Baffin Bay, however, less ice and a higher surface temperature than normal was found.

1876. In Baffin Bay more ice occurred than the previous year, yet perhaps not more than normal and in Davis Strait the extension of the ice was normal. The temperatures in the Baffin Bay seem to have been above normal; we have no information about Davis Strait.

1881 and 1882 were cold ice-years with low surface temperature; in 1882 however the temperature of the warm water perhaps did not pass below the normal.

The summer of **1883** showed great extension of the Storis and extraordinarily great extension of the water of the polar current. This year the influence of the atlantic water was so weak that nowhere outside the fjords was water found which could be classed as of atlantic origin. We cannot say, therefore, how far out at sea and on how deep water the investigations should have been carried out to enable us to find the warm under-current. The observation material plainly shows that the cold water dominated that summer. In Baffin Bay the surface water was colder than normal; but at some depth the warm under-current was represented normally.

1884. The extension of the ice was great and the surface temperature on an average low. The polar current was extraordinarily weakly represented and could be traced no further than Fyllas Bank; but out in the Strait there was much atlantic water, even far north. At Lille Hellefiske Bank the warm water reached far up along the slope of the bank, but in the northern part of the strait it had difficulty in pressing away the cold intermediate water layer, and off Fyllas Bank it could not be demonstrated at all. Round Fyllas Bank the temperature of the upper water layers was normal or a little above, the temperature of the deeper water layers a little lower. In the deep parts of Disko Bay the atlantic water was strongly represented.

On the whole the summer did not differ much from the average.

From **1886** only few observations are available, but they seem to show that all water masses are warm in spite of the great extension of the ice; the atlantic under-current seems especially to have been dominating strongly.

1887 was a year with extraordinarily heavy ice; but on account of the few hydrographic observations available it can only be deducted that the summer cannot be classed as very cold.

1889. The extension of the ice was especially great and the surface temperature below the normal. All the same the summer was particularly warm due to extraordinarily strong influx of atlantic water and, at the same time, hardly any movement in the polar current, so that the latter was forced far out to sea. The Canadian polar current, however, was very broad, but only off Store Hellefiske Bank it was able to keep the atlantic current deep down and give colder water than normal to the slope of the bank itself.

1895 also was a warm summer with high sea temperature, although this was somewhat lower than in the summer of 1889. The polar current from south was but weak and left the coast quickly. The surface water was strongly heated, and the atlantic water considerably pronounced, off Helders Bank, though, it lay rather far out.

1908. A summer marked by different cold water masses. Everywhere south of Holsteinsborg the surface water was colder than normally. The polar current dominated along the southern part of the coast throughout the summer, and the warm under-current, which at the beginning of the summer lay very deep, and was colder than normally, missed its effect round the tops of the banks where the temperature stayed below 1° C. the whole summer. Only at Store Hellefiske Bank did the under-current gradually reach so far that at the end of August it caused the temperature to rise to 2—3° C. at 70—100 m depth, which temperature, however, was lower than normal. Into Disko Bay there had only been a small influx of atlantic water.

1909. At the beginning of the summer the atlantic under-current had great vertical extension, was very warm but weak (stagnant remainder from the previous summer). The cold water over the banks was colder than normally, but the polar current was weak. As to the later development the only fact known is that both the cold and the warm currents flowed at a good rate off the southern point of Greenland in September, and the temperatures of both currents were higher than normal. Possibly also the banks along the western coast were influenced by the warm water.

1916. Regarding this summer we only know that the warm under-current in Disko Bay did not prevail much, but its temperature was normal in Baffin Bay.

1924. This summer must be characterized as one of the warmest, the atlantic under-current had an extraordinarily great vertical extension, was warm, the upper water layers being much warmer than normally in accordance with the high temperature of air. But the Canadian polar current was so broad that it washed the outer slopes of the Hellefiske Banks as a thin water layer throughout the summer, while the East Greenland polar current in the middle of the summer reached as far as Fyllas Bank, and caused, on a level with its top, a strong decrease in temperature perhaps as far down as to 0° C.

1925 was again a cold summer where cold water of different origins play an important part on a level with the tops of all the banks. To the southern banks the polar current carried water with negative temperature on about July 1st, and over the northern banks lay the very cold winter cooled water. The atlantic under-current was, on an average, colder than normally and flowed rather deeply most of the summer.

For the summer of **1926** our knowledge is of the upper water layers only, and these were very warm throughout the summer; partly because the supply of heat from above was very strong and partly because the temperature of the polar current was high. This summer reminds us in many ways of 1924, but apparently the strong advance of cold water in the month of July did not occur.

1928 was a warm summer. The supply of heat to the surface layers was great, the temperature thus rising considerably above the normal along the whole western coast. Also the two currents from the south were strong, and both of them carried warmer water than normally, especially the polar current; whereever they appeared they caused positive deviations in the temperature. The high temperature of the polar current could be traced as far as the southern point of Lille Hellefiske Bank, and although it advanced greatly in the middle of the summer this caused but a short delay in the rise of temperature. The effect of the warm under-current reached as far as the ridge off Holsteinsborg.

From **1931** some series of observations from the most southern part of Davis Strait are available, and they show that the warm under-current prevailed strongly, while the polar current apparently stretched far out at sea as far south as off Ivigtut.

1933. The summer was apparently dominated by the warm under-current as was the case in 1931. Observations of both years in all are very alike.

1934. Of all years where hydrographic investigations have been carried out in Davis Strait this summer seems to be the warmest. In spite of the fact that the temperature of the air was only a little above the normal, the upper water layers were extremely warm and the rise of temperature considerable during the summer. The atlantic under-current showed a great positive deviation in temperature also, and it reached far up on the outer slopes of the banks. At the top of Fyllas Bank the polar current appeared during the summer, but probably it caused here only a temporary pause in the rise of temperature.

1936. As in 1934 all water masses were extraordinarily warm as early as at the beginning of the summer, and the atlantic under-current had an exceptionally great vertical extension. The advance of the polar current in the middle of the summer was somewhat more pronounced than in 1934, but except for this the two years were equally warm.

1937. Over the banks the temperature was normal or a little higher, and the advance of the polar current did not seem to have caused any serious cooling of Fyllas Bank, even if has been able to keep the atlantic under-current down at a greater depth than normally.

Some observations from the fjords show very low temperatures, unlike the previous years. This may be due to the cold weather which prevailed both during the summer and the previous winter, and may thus have no connection with the hydropraphic conditions out in the strait.

The summer of **1938** probably belongs to the coldest of all, but observations from this year are very scarce. All water masses in the vicinity of the banks were very cold in the early summer and perhaps without any motion. The atlantic under-current could not be demonstrated off Fyllas Bank, unless the fact was that it was colder than as observed on any other expedition. During the summer it reached but a little up along the outer slope of the bank and at the top of the bank the cold water of the polar current lay as late as the end of August.

Also this year the temperature was very low in the fjords. The weather continued to be cold.

From this survey it appears that the hydrographic conditions off the western coast of Greenland have varied rather considerably during the last half century. Unfortunately years from which no hydrographie observations are available form the majority, and also observations from many of the expeditions are so scarce and scattered that is has been impossible to undertake dynamic computations or any other thorough investigation as to the character and movement of the volumes of water. Accordingly, no coherent view of the variations within this space of time is given, but we are able to say that apparently a relative warm period sets in during the years of 1880, and was still (or again) present in 1895. Evidence is available of colder water in the first part of our century, until the year 1926 begins a new warm period with considerably warmer water than in the decade beginning 1880. This period culminated in 1934, 1936 was still very warm, 1937 fairly normal and 1938 very cold. The observations of the latter years, however, were made so close to the banks as to give us but little information about the currents out in the strait.

The previous chapter plainly shows that, from various causes the temperatures of the sea off West Greenland may vary irregularly. As a rule they are due to shifting inter-

actions of the main currents, or due to the fact that the currents themselves carry more or less warm water; the weather and other local phenomenona may also have influence. But while we are able, to a certain degree, to explain which are the specially determining factors in every case, we are in fact unable to answer the question why this or that factor especially occurs in the year concerned.

Very often an evident relation between the temperature of air and the surface temperature of the sea appears, a fact which seems quite natural. But as soon as we begin to study the extension of the ice compared with, for instance, the surface temperature conflicts, frequently appear which as a rule are due to the dependence of the ice on the wind. Also between the meteorologic factors and the temperature of the sea currents there is rarely any accordance. The reasons for these variations in the characters of the currents cannot be found in local conditions, as the currents both off Greenland as in other places, are closely attached to the great current systems which in their turn are dependent on the general atmospheric circulation round the whole earth. R. Scherhag [1]) for instance calls attention to the fact that the barometric gradient between the subtropic and continental high pressure on one hand and the low pressure of the air at the polar front on the other has intensified much during the last 10 to 20 years (it could be traced as early as in the ten years from 1911—1920) and this fact must of course involve an increase in the south westerly winds between about 35° and 65° Lat. The consequence is thus that great masses of warm air are carried with the wind up over the Norwegian Sea, Europe and the northern part of Siberia. At the same time also the rates of the great drift currents and possibly their extension also are increased and they are able therefore to carry greater volumes of water northward than they did before.

Such an alteration in the climate must, by the nature of the case, spread widely, and changes have actually been demonstrated everywhere in the arctic regions. At Jacobshavn the temperatures of the air have been about 5° C. higher during the winter months in the ten years 1923—1932 than at the century end. At North and East Iceland the temperature of the sea has risen much. North of Siberia the sea ice has retreated considerably, and on the continent the area of the ground ice has been diminished. On Svalbard the winter months of 1931—1935 were warmer by 9° C. than in 1911—1920 and on Franz Joseph Land a corresponding rise of 7° C. took place.[2])

In relation to this alteration of climate in the arctic regions it ought to be mentioned that a rise of 0.4° C. has been demonstrated in the temperature of the Gulf Stream in Florida Strait, but this rise is but of small importance compared with the increased transport of atlantic water to the cold seas.

An increase of the atmospheric circulation everywhere on the earth is most assuredly not due to factors here, rather it must be looked for among cosmic phenomenona, perhaps the activity of the sun.

[1]) R. Scherhag 1936, 1937.

[2]) Ad. S. Jensen. 1939 (or report in Naturhistorisk Tidende 1939).

Literature.

Baggesgaard-Rasmussen and J. P. Jacobsen (1930): Contribution to the Hydrography of the Waters round Greenland in the Year 1925. — Medd. fra Komm. for Havundersøgelser. Serie: Hydrografi, Bd. II. København.

Böhnecke, G. m. fl. (1930): Über die hydrographischen, chemischen und biologischen Verhältnisse an der Meeresoberfläche zwischen Island und Grønland. Ergebnisse einer Fahrt mit dem Vermessungsschiff "Meteor" im August 1929. — Ann. d. Hydr. Hamburg.

— m. fl. (1932): Beiträge zur Ozeanographie des Oberflächenwassers in der Dänemarkstrasse und Irminger See. II. Teil. — Ann. d. Hydr. Hamburg.

Conseil Permanent International etc.: Bull. Hydrographique. København.

Defant, A. a. o. (1936): Die ozeanographischen Arbeiten des Vermessungsschiffes "Meteor" in der Dänemarkstrasse und Irmingersee wärend der Fischereischutzfahrten 1929, 1930, 1933 und 1935. I. Teil. Plan und Reiseberichte. Die Tiefenkarte. Das Beobachtungsmaterial. — Veröff. d. Inst. für Meereskunde, Berlin. N. F. A. Geogr.-nat. Reihe. H. 32. Berlin.

Hamberg, A. (1884): Hydrografisk-kemiska Iagttagelser under Den Svenska Expeditionen till Grønland 1883. — Bihang till Kungl. Svenska Vet. Akad. Handlingar. Bd. 9. Stockholm.

Irminger, C. (1843): Golfstrømmens Hastighed. Strømmen ved Island m. m. — Archiv for Søvæsenet. I. Række. Bd. 15. København.

— (1853): Om Havets Strømninger m. m. — Ny Archiv for Søvæsenet. II. Række. Bd. 8. København.

— (1854): Den arktiske Strømning. — Nyt Archiv for Søvæsenet. II. Række. Bd. 9. København.

Jensen, Ad. S. (1939): Concerning a Change of Climate during recent Decades in the Arctic and Subarctic Regions, from Greenland in the West to Eurasia in the East, and contemporary Biological and Geophysical Changes. — Kgl. Danske Vidensk. Selsk. Biol. Medd. XIV, 8. København.

Kiilerich, A. B. (1933): Nordvandet, Forsøg paa en Forklaring af det isfri Havomraade i Smith Sund. — Geogr. Tidsskr. København.

— (1936): Svingninger i de hydrografiske Forhold ved de vestgrønlandske Fiskebanker. — Beretn. om det 19. skand. Naturforskermøde, Helsinki d. 11.—15. Aug. 1936, Helsinki.

— (1939): The Godthaab Expedition 1928. A Theoretical Treatment of the Hydrographical Observation Material. — Medd. om Grønland. Bd. 78. Nr. 5. København.

Knudsen, M. (1898): Den danske Ingolf-Ekspedition. I. Hydrografi. København.

— (1923): Dr. Thorild Wulff's Hydrographical Investigations in the Waters West of Greenland. — Medd. om Grønland. Bd. 64. København.

Loewe, F. (1935): Hydrographische Untersuchungen in Fjorden Westgrönlands. — Arctica. Leningrad.

— und E. Sorge (1933): Wissenschaftliche Arbeiten in Westgrönland. — Forschungen und Fortschritte. Berlin.

Martens, E. (1929): Hydrographical Investigations during the "Michael Sars" Expedition 1924. — Rapp. et Procès-Verbaux des Réunions etc. Vol. 56. København.

Mecking, L. (1906): Die Eistrift aus dem Bereich der Baffin-Bai, beherrscht von Strom und Wetter. — Veröff. Inst. für Meereskunde. No. 7. Berlin.

Meinardus, W. (1904): Über Schwankungen der nordatlantischen Zirkulation und Ihre Folgen. — Ann. d. Hydr. Hamburg.

— (1906): Periodische Schwankungen der Eistrift bei Island. — Ann. d. Hydr. Hamburg.

Meteorologisk Institut (1893—): Isforholdene i de arktiske Have. — Tillæg til Nautisk-Meteorologisk Aarbog. København.

Mikkelsen, E. (1915): Notes on the Sea-Ice along the Eastcoast of Greenland. Alabamaekspeditionen til Nordøst-Grønland 1909—1912. — Medd. om Grønland. Bd. 52. København.

Nansen, F. (1912—13): Das Bodenwasser und die Abkühlung des Meeres. — Internat. Revue der gesamten Hydrobiologie und Hydrographie. Bd. 5. Leipzig.

Nielsen, J. N. (1913): Bearbejdelse af det paa "Tjalfe"-Ekspeditionerne 1908 og 1909 indsamlede hydrografiske Observationsmateriale. — Manuscript. København.

— (1928): The waters round Greenland. — Greenland. Vol. I. København.

Riis-Carstensen, E. (1936): The "Godthaab" Expedition 1928. The hydrographic work and material. — Medd. om Grønland. Bd. 78. Nr. 3. København.
Ryder, C. (1895): Den østgrønlandske Expedition udført i Aarene 1891—92. V. Hydrografi. — Medd. om Grønland. Bd. 17. Nr. 3. København.
Scherhag, R. (1936): Die Zunahme der atmosphärischen Zirkulation in den letzten 25 Jahren. — Ann. d. Hydr. Hamburg.
— (1937): Eine bemerkenswerte Klimaänderung über Nordeuropa. — Ann. d. Hydr. Hamburg.
Shirshov, P. and E. Fedorov (1938): Scientific Work of the Drifting North Polar Station. — Nature. London.
Smith, Edw. H., F. M. Soule and O. Mosby (1937): The Marion and General Greene Expeditions to Davis Strait and Labrador Sea 1928—1931—1933—1934—1935. Scientific Results. Part 2, Physical Oceanography. — U. S. Treasury Dep. Coast Guard, Bull. No. 19. Washington.
Speerschneider, C. I. H. (1931): The State of Ice in Davis-Strait 1820—1930. — Publ. fra Det Danske Met. Inst. Medd. Nr. 8. København.
Sverdrup, H. U. (1933): Narrative and Oceanography of the Nautilus Expedition 1931. — Publ. fra Chr. Michelsens Inst. No. 25. Papers in Physical Oceanography and Meteorology. Massachusetts Inst. of Technology. Vol. II. No. 1. Massachusetts.
Vahl, M. m. fl. (1928—29): Greenland I, II, III. København.
Wandel, C. F. (1893): Om de hydrografiske Forhold i Davis-Strædet. — Medd. om Grønland. Bd. 7. København.
Wüst, G. (1930): Der Golfstrom. — Zeitschr. d. Gesell. f. Erdkunde zu Berlin. Berlin.

Dansk Resumé.

Havomraadet udfor Sydgrønlands Vestkyst er næsten fuldstændig under Indflydelse af de Vandmasser, der rundt om Kap Farvel føres med Strømmene fra Østgrønland, nemlig den østgrønlandske Polarstrøm og Irmingerstrømmen.

Polarstrømmen har sit Udspring i Polhavet og Grønlandshavet, hvorfra den som en Overfladestrøm passerer over Tærsklerne saavel mellem Grønland og Svalbard som mellem Grønland og Island. Den er nøje knyttet til Shelfen. Ydergrænsen ved Havoverfladen kan sættes ved Isohalinen for 32‰, Undergrænsen ved 0° og 34,75‰, og Temperaturminimet paa ÷ 1,7—÷ 1,8° (33,50—34,00‰) ligger i 40—60 m Dybde.

Ved Indgangen til Danmark Strædet møder den den varme Irmingerstrøm og bliver af denne presset haardt over mod Grønland, idet der dog gennem stærk Hvirveldannelse finder Blanding Sted mellem de to Strømme. En ganske ringe Tilblanding af atlantisk, men temmelig koldt Vand skyldes den Gren af Golfstrømmen, der Vest om Svalbard strækker sig sydpaa langs Østgrønland under Polarstrømmen.

Naar Polarstrømmen runder Kap Farvel, er Temperaturen først paa Sommeren negativ i næsten hele Strømmens Bredde; men i Slutningen af Sommeren findes negativ Temperatur kun i et ganske lille Omraade tæt op ad Land, eller Temperaturen er steget helt til 2—3 eller 4°; Saltholdigheden er 32—34‰.

Ogsaa Irmingerstrømmen har ved Blandingen mistet meget af sine oprindelige Karakterer, saaledes at den i sine øvre Lag først paa Sommeren har Temperatur og Saltholdighed paa 3—5° og 34,00—34,75‰, medens Kærnen af Strømmen i 2—400 m Dybde har 4—5° og 34,75—35,00‰. I Løbet af Sommeren stiger Temperaturen i de øvre Vandlag til 6—8° og dybere nede til 5—6°; Saltholdigheden aftager derimod lidt.

Det er saaledes især Blandingsvand, der naar frem til Vestgrønland; dette gælder saavel Vandet i den saakaldte atlantiske Understrøm som i Polarstrømmen; og

ligesom Strømhastigheden langs Østgrønland er størst om Sommeren, saaledes opviser Tilstrømningen til Vestgrønland ogsaa en udpræget aarlig Periode.

Saavel Polarstrømmen som den varme Understrøm synes altid at være til Stede udfor Kap Farvel straks ved Sommerens Begyndelse (Maj—Juni), medens der endnu er strømløst nordpaa omkring Bankerne.

Ved Fiskenæs Bankernes og Fyllas Bankes Top er Temperaturen paa denne Aarstid som Regel 0—1° og Saltholdigheden 33,50—34,00 ‰; men Overfladevandet kan godt allerede have en Temperatur paa 1—2°. Over de nordligere liggende Bankers Top er der stillestaaende vinterafkølet Vand paa omkring 0 eller ÷ 1° og c. 34,00 ‰; men Temperaturen i et tyndt Overfladelag stiger hurtigt, saa snart Vinterisen og Vestisen er væk.

Over Fyllas Banke stiger Overfladetemperaturen normalt Sommeren igennem, saa den ved Udgangen af Juni er naaet til 2—3° eller i særligt varme Aar til 4—5°; i Løbet af Juli naar den gennemsnitlig til 3—4° og i August og September til 6—8°, i særligt varme Aar endda 1 eller 2° højere. Men paa Ydersiden af Banken, i c. 100 m Dybde, vil Polarstrømmen i de fleste Tilfælde engang midt paa Sommeren modarbejde Temperaturstigningen, idet den paa denne Aarstid opnaar sin største Hastighed og paa Grund af Jordrotationen presses haardere ind mod Bankens Side. I Tilfælde hvor dens Hastighed er lille, vil den kun i ringe Grad gøre sig gældende, og Temperaturen vil ved Banken blive staaende paa c. 2° hele den midterste Del af Sommeren (Tavle II, 2), medens Temperaturen i Aar med stærk og kold Polarstrøm vil synke til 0° eller derunder (Fig. 3 og Tavle II, 1). I de Aar, hvor Polarstrømmen selv er varm, stiger Temperaturen uden Afbrydelse Sommeren igennem til 4—5° (Tavle II, 3).

Da dette Fremstød af koldt Vand normalt foregaar i 50—150 m Dybde, paavirkes Overfladetemperaturen kun i mindre Grad deraf.

Polarstrømmen plejer at slække af inden Midten af August, og herefter trænger det varme Vand frem baade fra oven og fra neden; men er det kolde Fremstød kommet saa sent som midt i Juli eller senere, bliver der dog næppe Tid til, at Vandet omkring Bankens Top kan naa op over 2°.

Bankerne Syd for Fyllas Banke er i endnu højere Grad under Indflydelse af Polarstrømmen, saa her maa man hvert Aar regne med den Mulighed, at det kolde Vand midt paa Sommeren kan strømme ind over dem; men mod Slutningen af Sommeren er alt Vand tit saa opvarmet og opblandet, at man bortset fra et ganske lille Omraade tæt under Kysten kan maale baade 3, 4 og 5° i alle Dybder,

Over de nordligere liggende Banker, Helders Banke og Store Hellefiskebanke, gør Polarstrømmen sig ikke gældende, idet den spredes ved Sydspidsen af Lille Hellefiskebanke. Den svage nordgaaende Strømning over disse Banker bestaar mest af lokalt Blandingsvand. Her bliver det vinterafkølede Vand med Temperatur paa 0° eller derunder tit liggende til langt hen paa Sommeren; men har Isen forladt disse Omraader tidligt, kan Opvarmningen af Overfladevandet i en varm Sommer tage hurtig Fart og skaffe 4—6° i de øverste 50 m og dermed til de øverste Toppe af Bankerne. Over den største Del af disse Banker, hvor Dybden er omkring 100 m, vil Temperaturen derimod tit holde sig paa 1—2° hele Sommeren igennem.

Den canadiske Polarstrøm optager normalt langt over Halvdelen af Davis Strædets nordlige Indgang og naar tit saa langt mod Øst, at den i 100—200 m Dybde beskyller den vestlige Skraaning af Store Hellefiskebanke med Vand paa 0—1° og c. 34,00 ‰ og dermed hindrer Tilstrømning af varmere Vand fra neden.

Den varme Strøm, som ligger udenfor og dybere end Polarstrømmen, viser lignende aarlig Periodicitet. Ved Sommerens Begyndelse, medens der kun udfor Grønlands Sydspids er nævneværdig Bevægelse, findes det varme Vand længere mod Nord som en stillestaaende og dybtliggende (4—700 m) Rest af forrige Aars Strøm.

Efterhaanden som den varme Strøm i Løbet af Juli og August kommer rigtigt i Gang, nærmer den sig til Land, og Grænsen mod det overliggende koldere Vand hæver sig op langs Bankernes Yderskraaning (se Skema Side 18 for Dybden af 3° Isotermen). Medens varmt Vand paa 3° kun sjældent naar op over Bankernes Kant, naar Vand med 2° i alle de relativt varme Aar op over de sydlige Banker og i flere Tilfælde ogsaa op over Kanten af Store Hellefiskebanke; og hvis det varme Vand nedefra først naar saa højt op, at det faar Forbindelse med Opvarmningen fra oven, er der Udsigt til en stærk og hurtig Opvarmning af Vandet omkring Bankernes Top (3—5°).

Den varme Understrøm naar sit Maksimum sent paa Efteraaret eller hen paa Vinteren og vil da antagelig skylle ind i alle Render og dybe Fjorde og maaske op over Bankerne. Naar Strømmen derefter er gaaet i Staa, vil det varme Vand i den nordlige Del af Davis Strædet ligge godt beskyttet under det kolde Overfladevand, saa vi næste Foraar netop her kan finde de højeste Temperaturer (4—5°), højere end længere mod Syd.

Havtemperaturen omkring de vestgrønlandske Fiskebanker er saaledes først og fremmest afhængig af, hvilken af de to Hovedstrømme, der har den største Energi; men disse Strømme saavel som Kystvandet kan jo i de forskellige Aar selv være mere eller mindre opvarmede.

Med Forskydning i Strømmenes indbyrdes Ligevægt i Løbet af Sommeren kan der følge vertikale Bevægelser i Vandet, saaledes at der med den varme Strøms Fremgang følger opstigende Vandbevægelse langs Bankerne, og iøvrigt maa der i Davis Strædet som Helhed være overvejende Strømning opad, eftersom der til de dybere Vandlag er en stærk Tilstrømning fra Atlanterhavet og i de øvre Vandlag en stærk Afstrømning mod Syd.

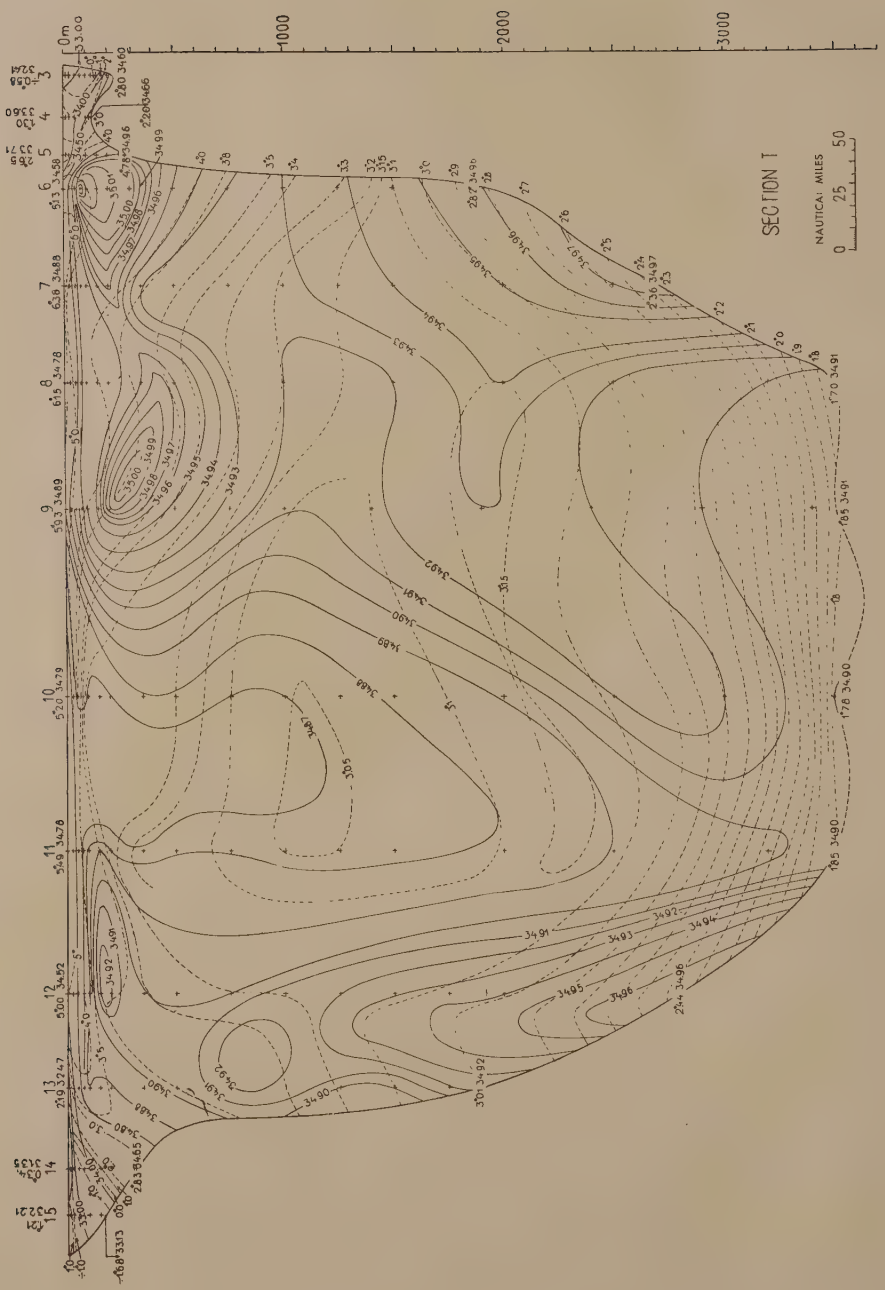
De hydrografiske Tilstande udfor Grønlands Vestkyst har varieret ret betydeligt i Løbet af det sidste halve Aarhundrede. Da de Aar, fra hvilke vi har hydrografiske Observationer, dog er faa og spredte, er vi imidlertid ikke i Stand til at følge Variationernes Forløb i Sammenhæng; men det ser dog ud til, at en relativt varm Periode satte ind i Løbet af 1880-erne, og at denne endnu (eller igen) var til Stede 1895; fra den første Del af vort Aarhundrede har vi Vidnesbyrd om koldere Vand, indtil vi i 1926 gaar ind i en ny Varmeperiode med betydeligt varmere Vand end i 1880-erne; denne Periode naaede sin Kulmination i 1934; 1936 var endnu meget varm, 1937 næsten normal og 1938 meget kold. Fra disse sidste Aar har vi dog kun lidt Kendskab til Strømmene ude i Strædet.

Aarsagerne til disse Variationer skal ikke søges i de lokale meteorologiske Forhold; Havstrømmene saavel ved Grønland som andre Steder maa have nøje Tilknytning til de store Strømsystemer, der selv igen er paavirkede af den almindelige atmosfæriske Cirkulation. Man har paavist en Forøgelse af denne Cirkulation i Løbet af de sidste 20—30 Aar, og dermed er fulgt stærkt forøget Varmetilførsel til de højere Breddegrader.

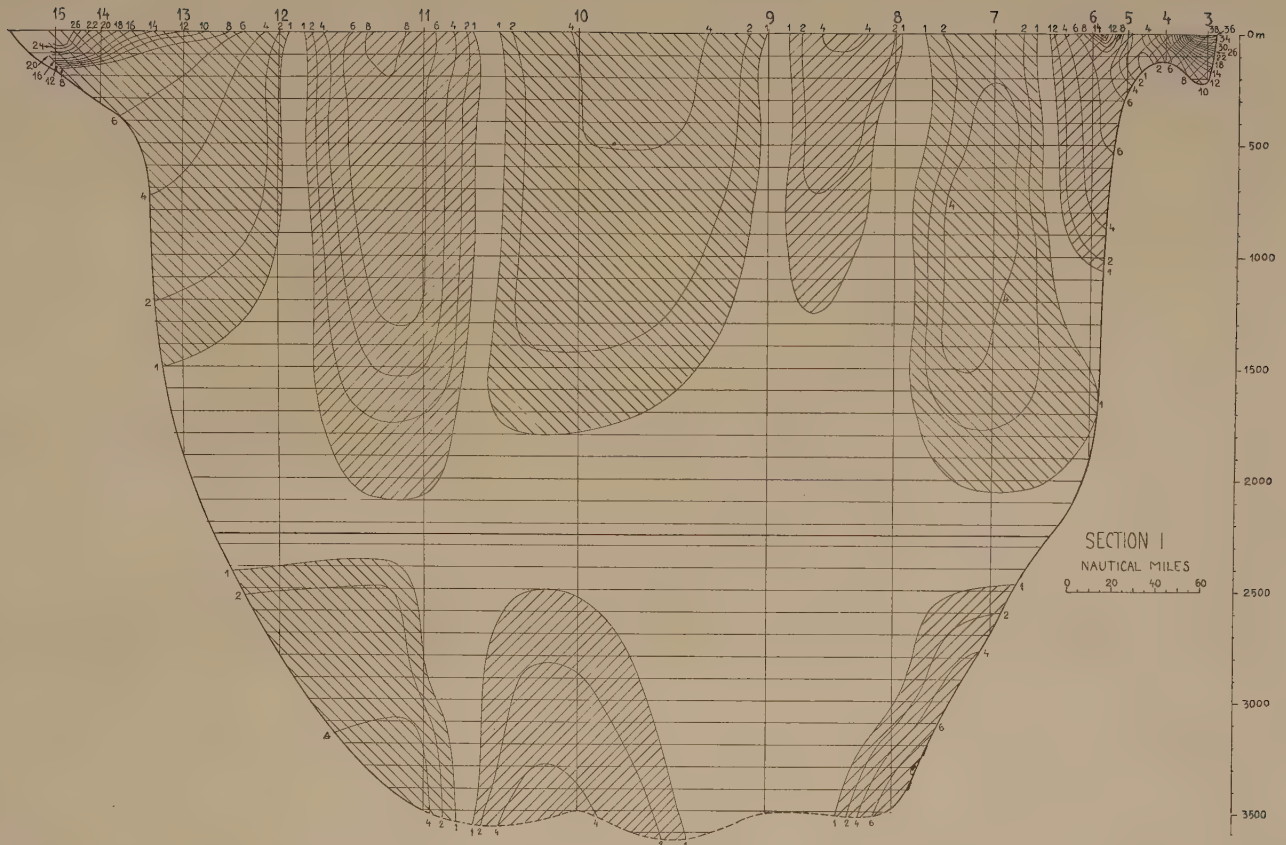
500—10.3. 1943

PLATES

Plate I, 1.

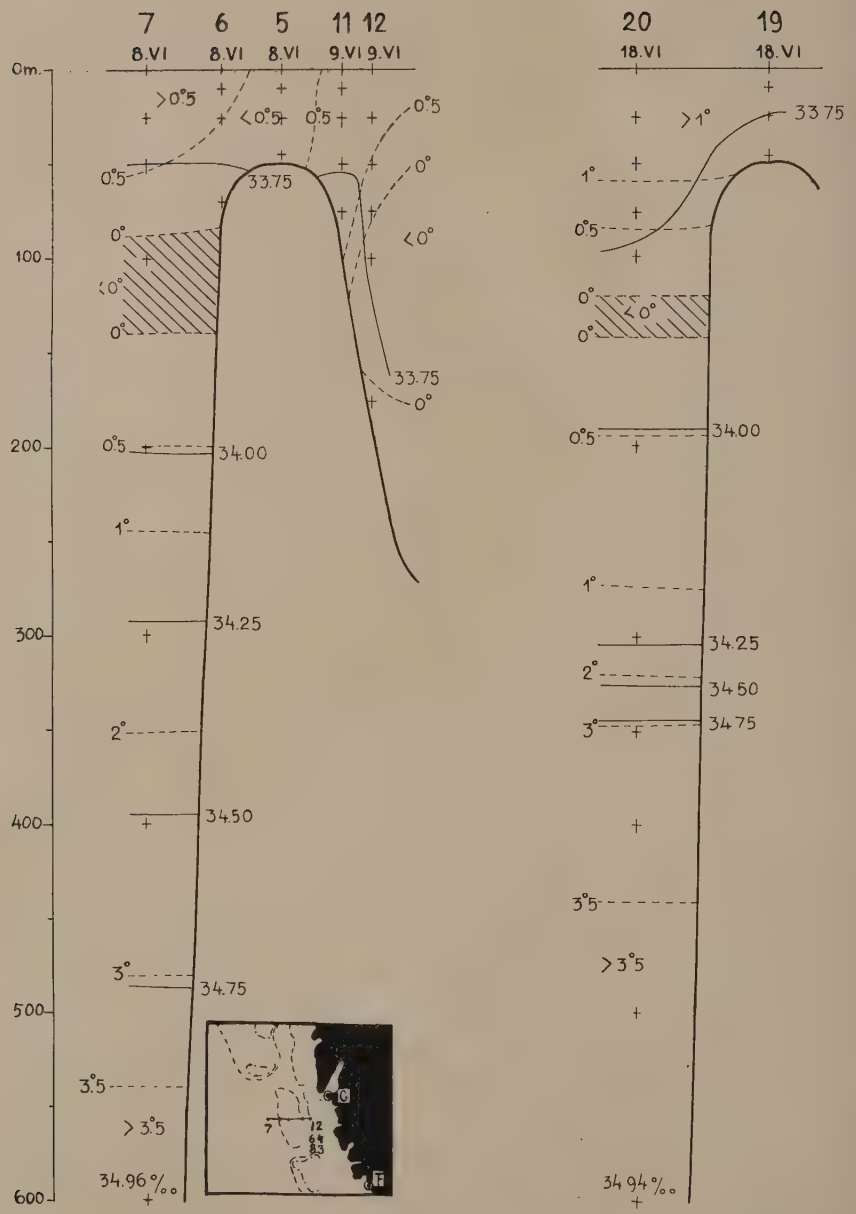


Hydrographic section. Cape Farewell-Labrador. May 28th to June 6th. 1928 (E. Ruis-Carstensen 1936).

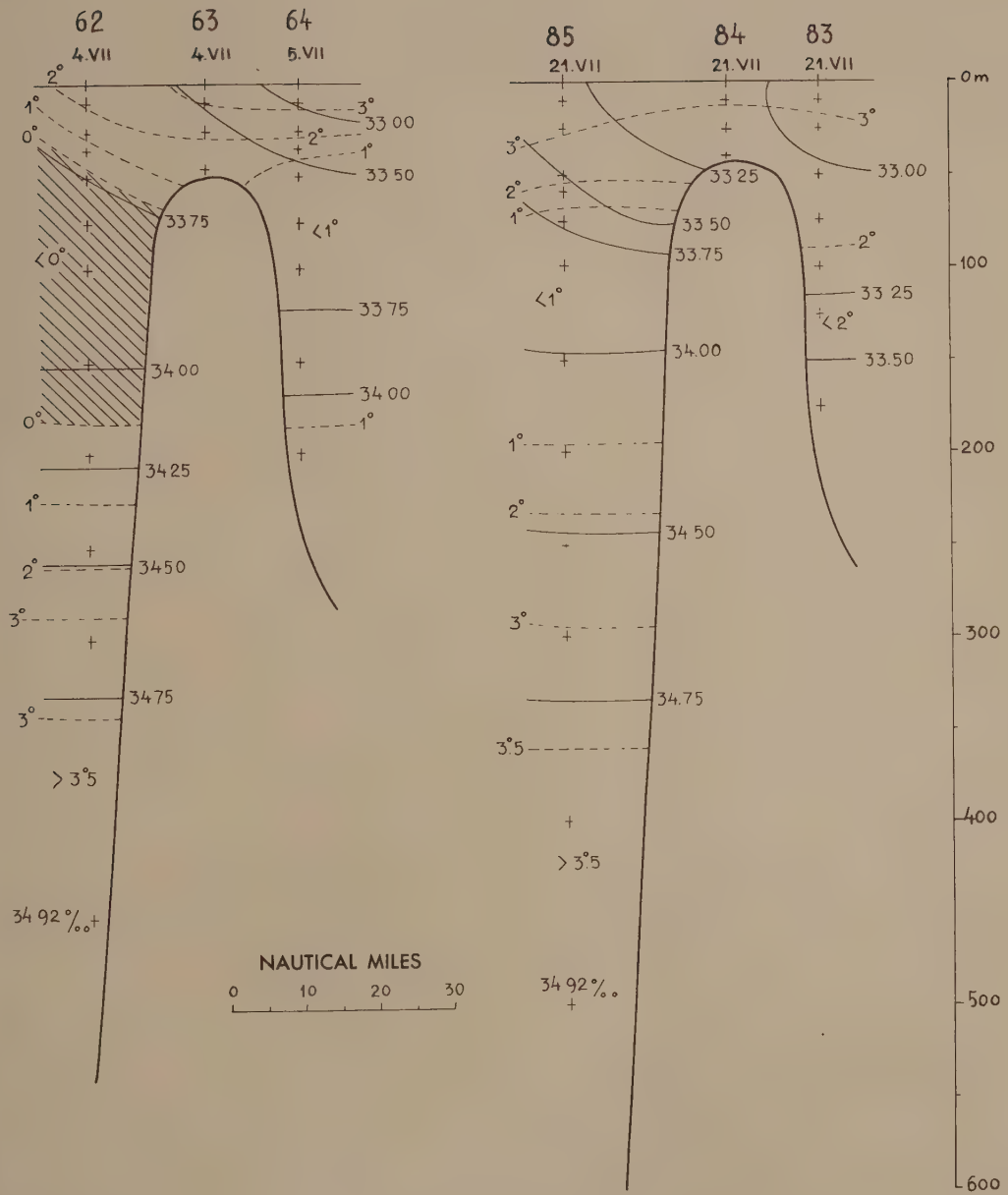


Vertical current section. Cape Farevell-Labrador. May 28th to June 6th. Velocity in centimetres sec^{-1}. Reference level at 2250 db. Hatching ascending to the right indicates that the current goes into the paper, hatching ascending to the left indicates that the current goes out of the paper. (A. Kiilerich 1939).

Plate I, 2.

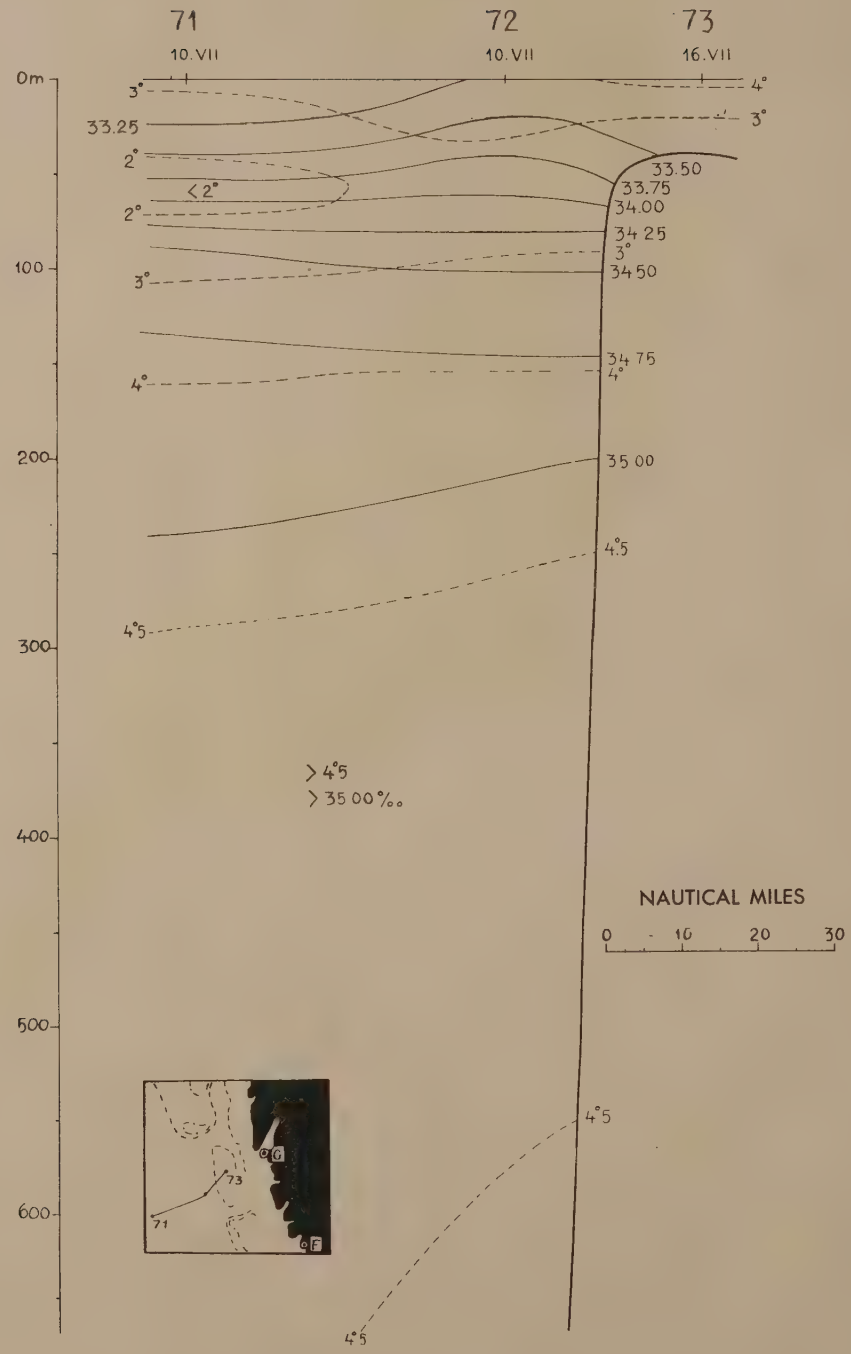


Hydrographic sections
1. 1925, instance of cold summer with extra

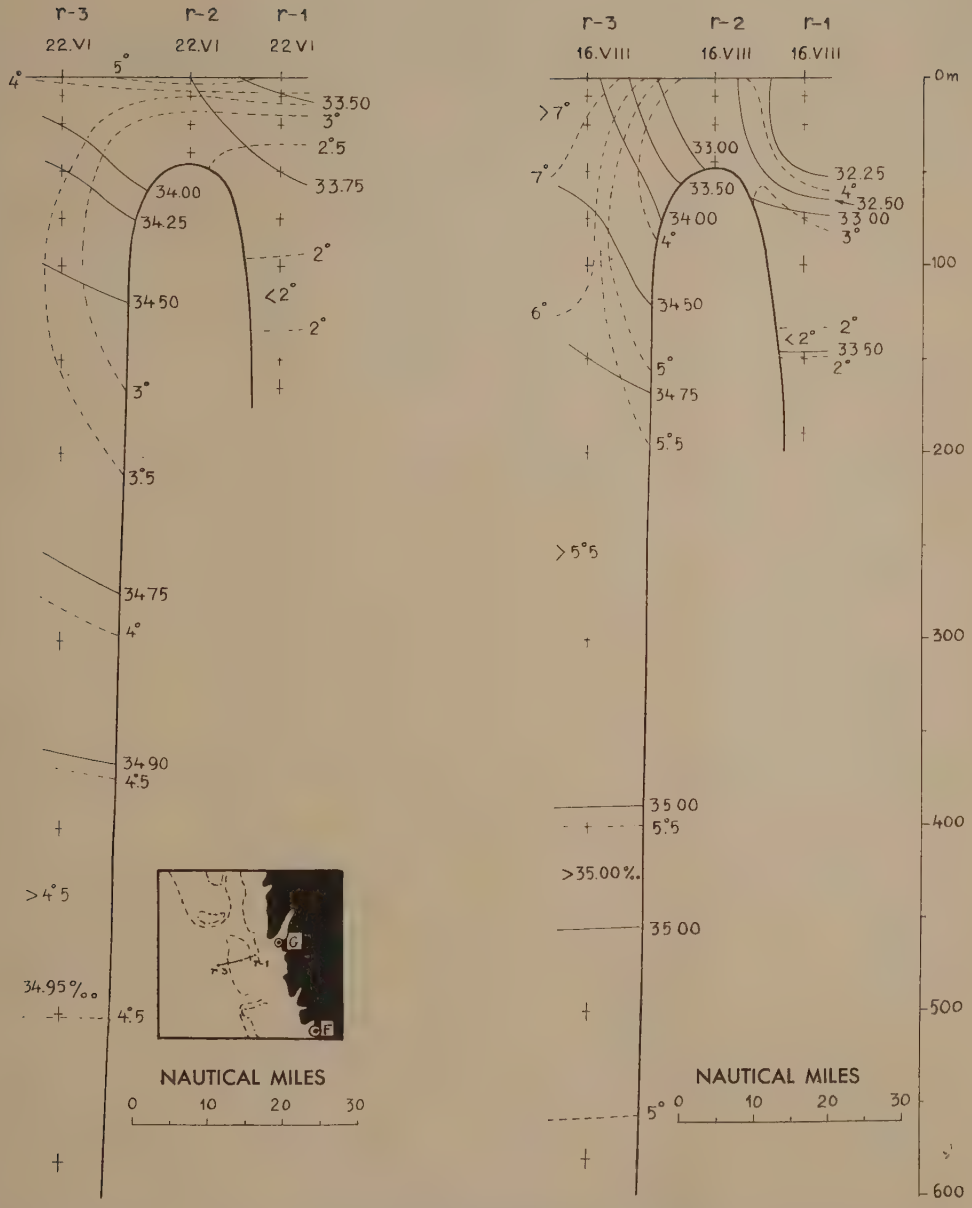


across Fyllas Bank.
ordinarily strong advance of the polar current.

Plate II, 2.



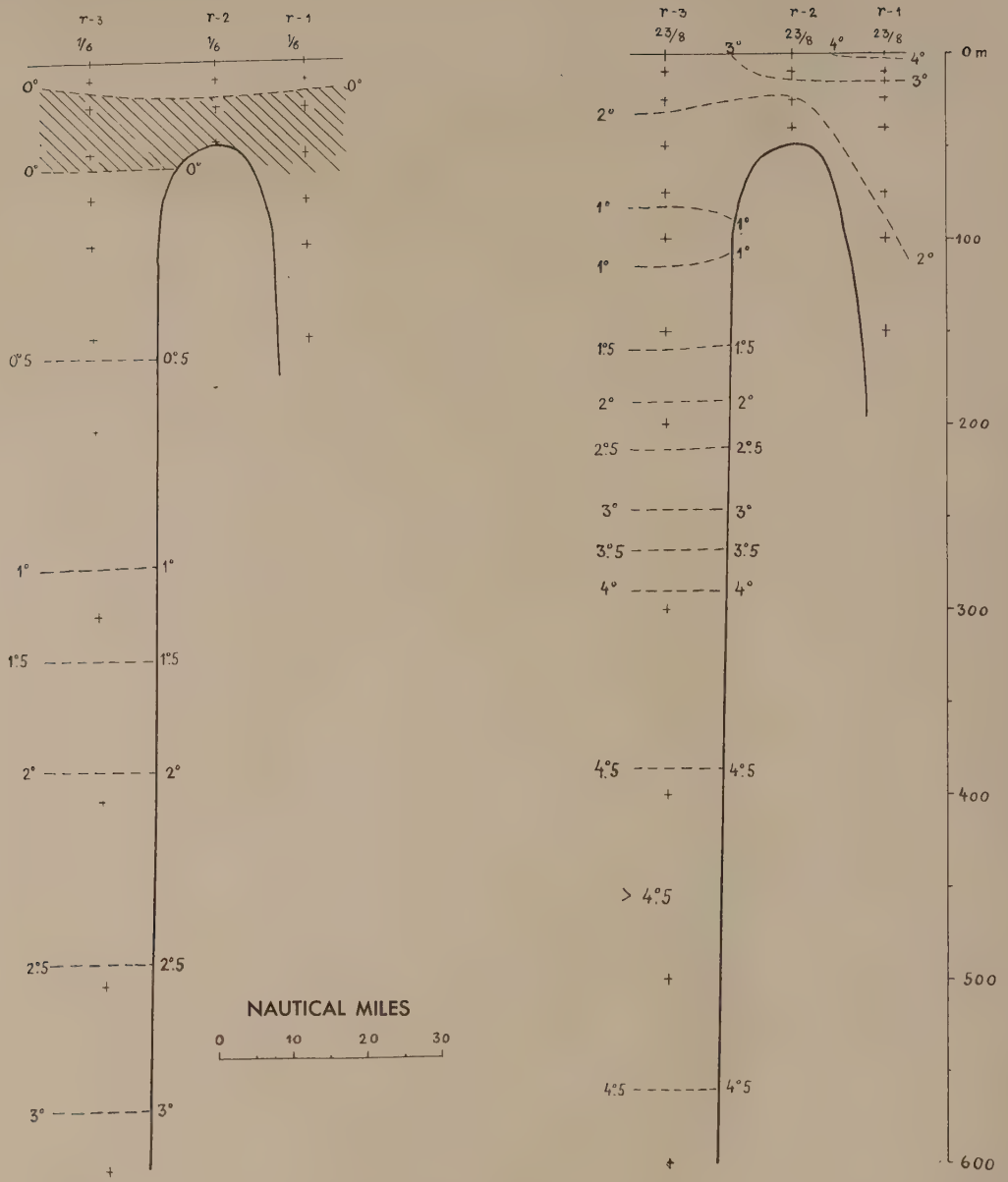
Hydrographic sections across Fyllas Bank.
2. 1889, instance of warm summer, where the polar current is very weak.



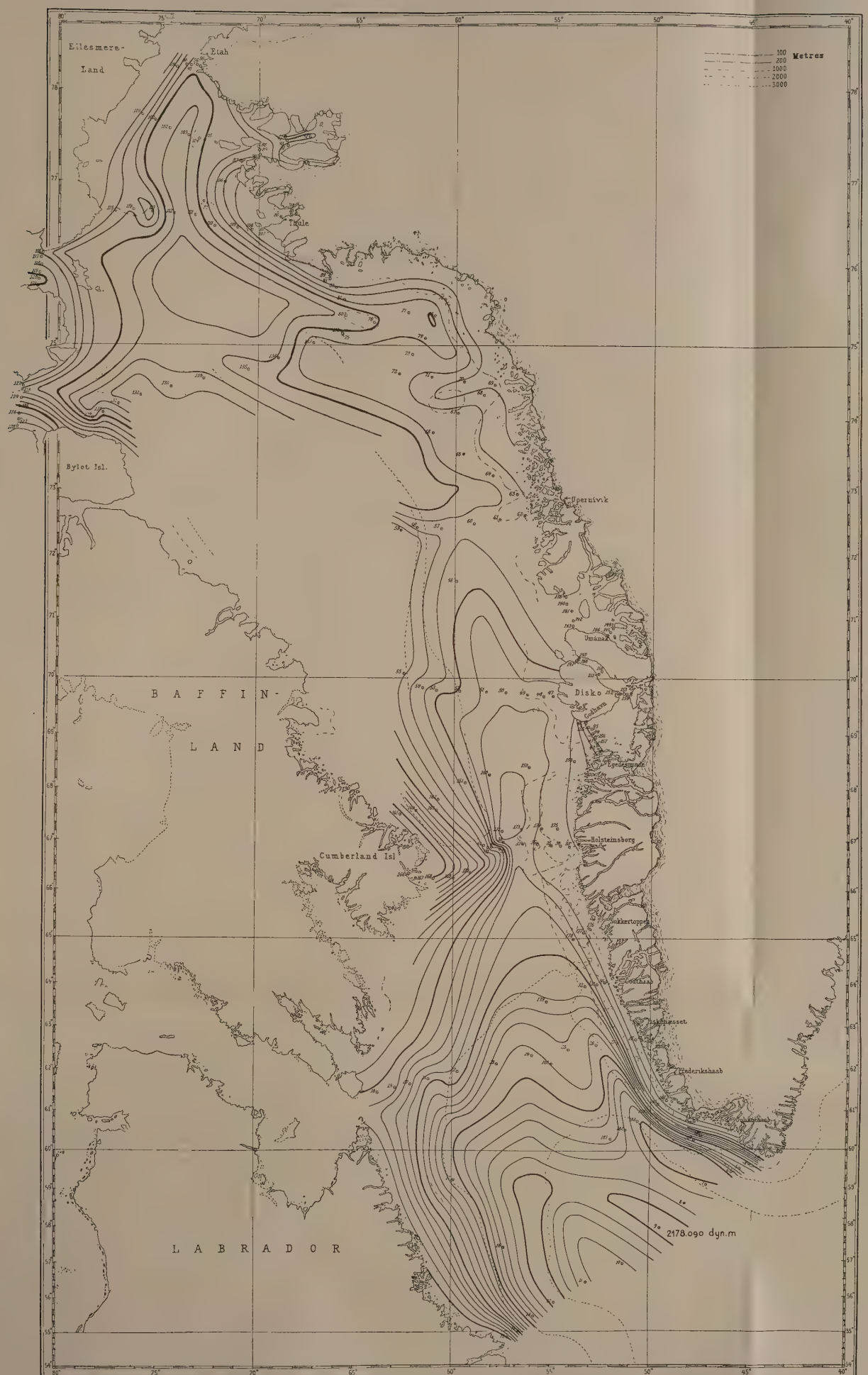
Hydrographic sections across Fyllas Bank.

3. 1934, instance of warm summer, where all water masses are very warm and the advance of the polar current weak.

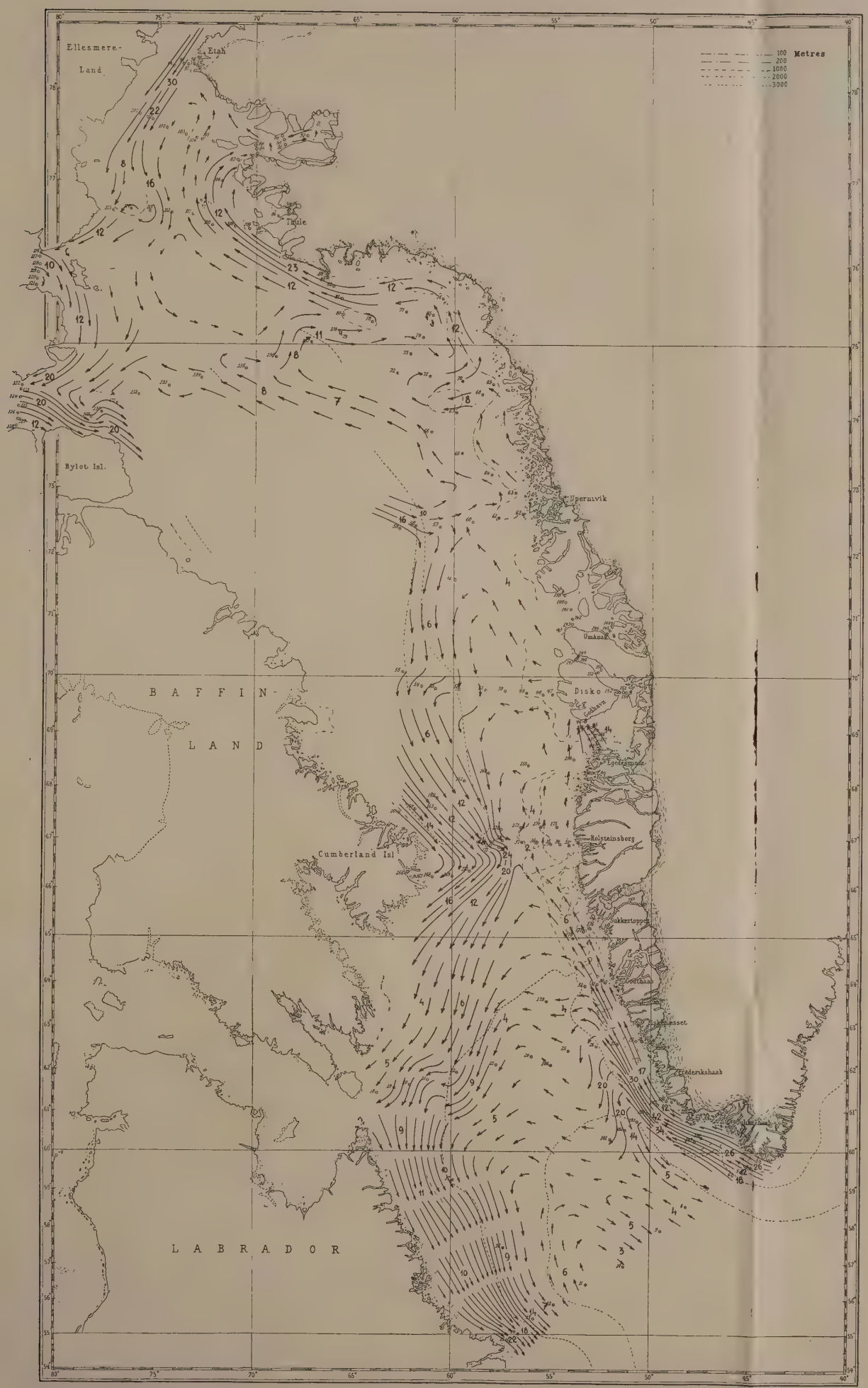
Plate III.



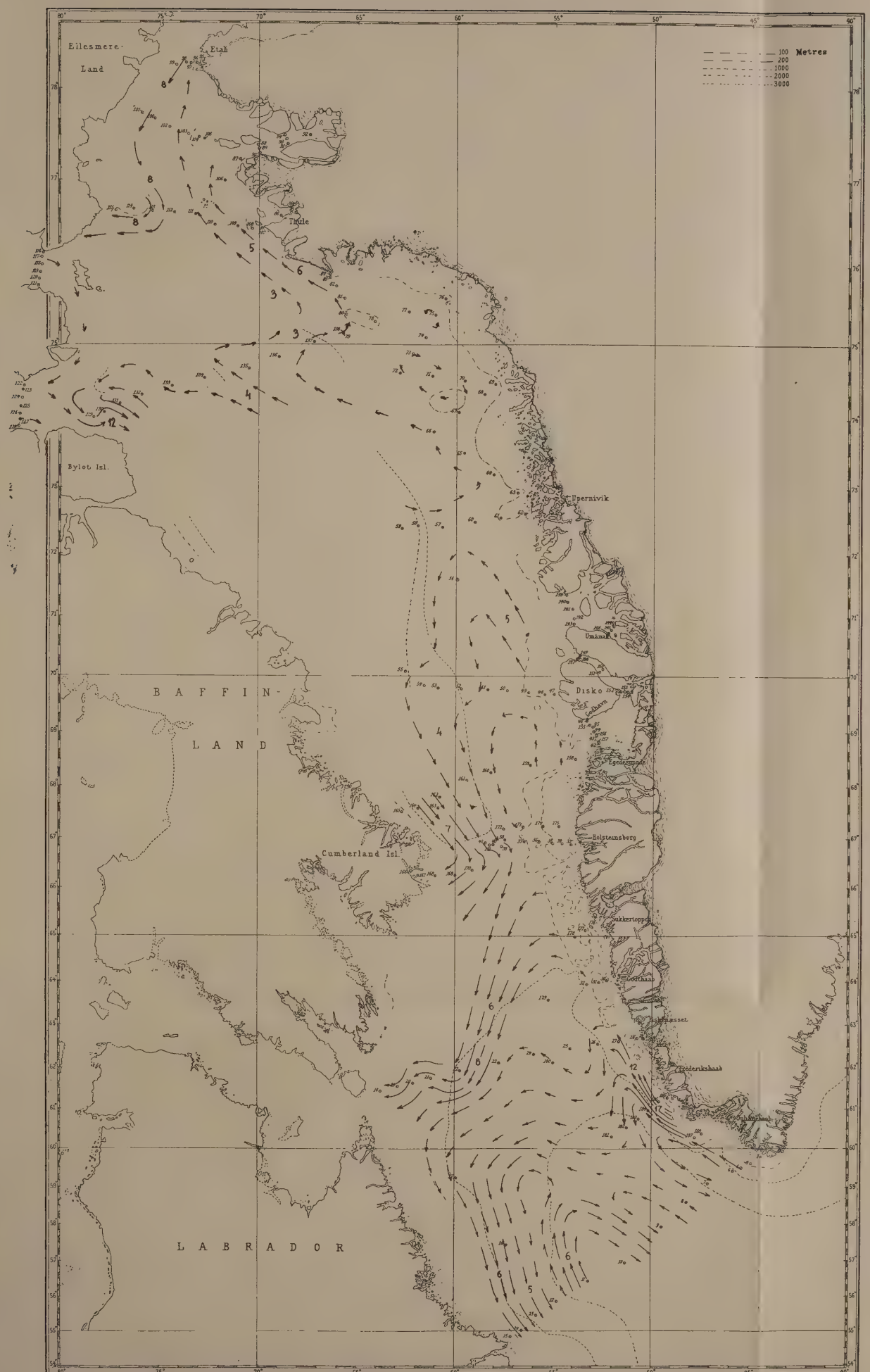
Hydrographic sections across Fyllas Bank.
1938. Instance of very cold summer, where all water masses are cold, and the warm undercurrent lies very deep.



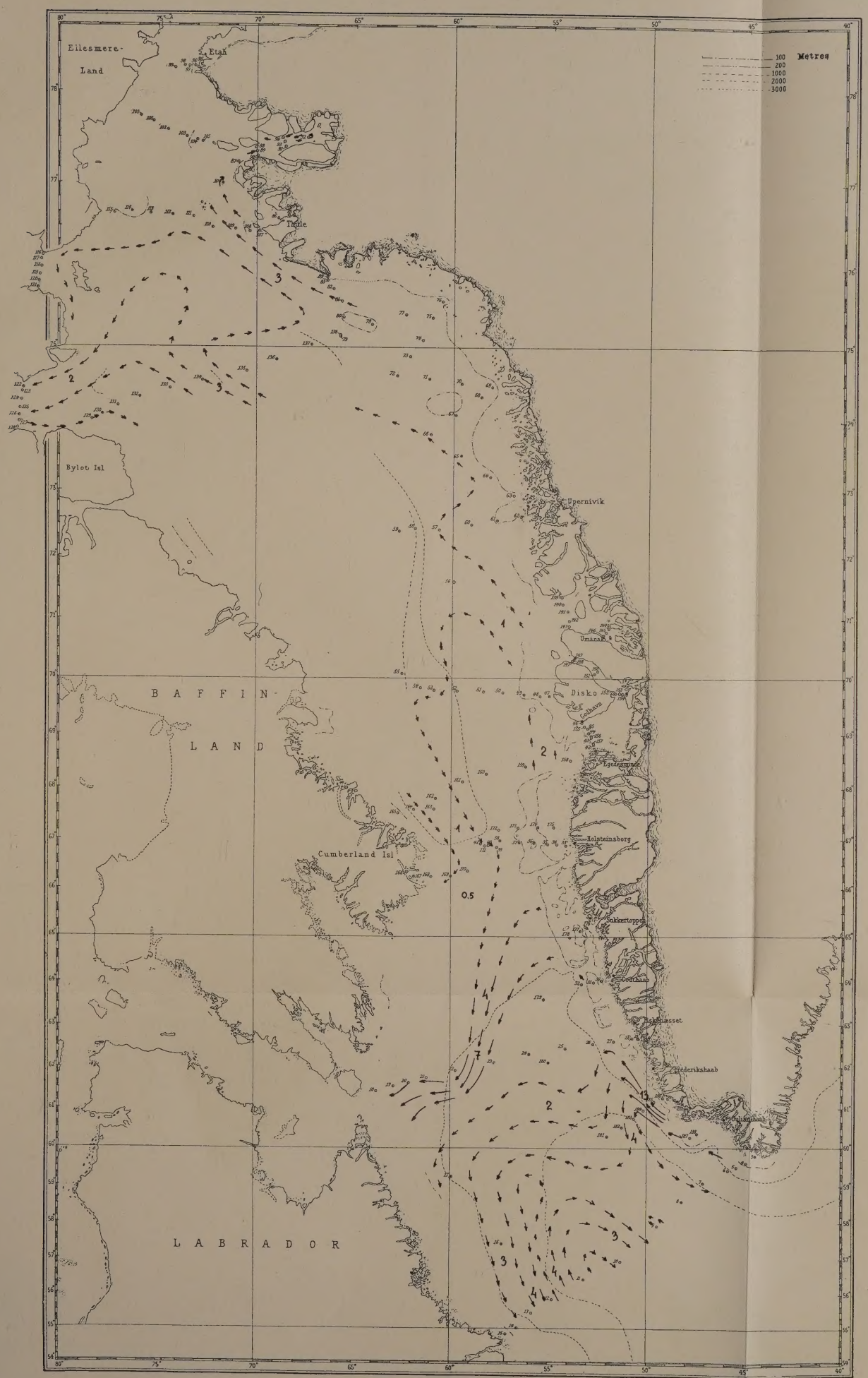
The topography of the sea surface calculated on the basis of a reference level, which to the South is placed at a pressure of 2250 db, off Fiskenæsset at 1250 db, across the ridge at 660 db, in Baffin Bay at 1000 db, and over the banks and in Disko Bay as in the sounds at 500 db. At station 9 the surface is 2178.090 dynamic metres over the reference level. The distance between the curves is 2 dynamic centimeres (A. Kiilerich 1939).



The currents at the sea surface. The reference level at varying depths in conformity with the reference level in plate IV. The figures in the map indicate velocity in centimetres sec^{-1}. (A. Kiilerich).



The currents at 200 metres. The reference level at varying depths as in plates IV and V. (A. Kiilerich 1939).



The currents at 500 m. The reference level at varying depths as in plates IV—VI. (A. Kiilerich 1939).

MEDDELELSER FRA KOMMISSIONEN FOR HAVUNDERSØGELSER

Serie: Hydrografi.

Bd. I, Nr. 1 MARTIN KNUDSEN: On the organisation of the Danish hydrographic researches. 1904. 7 p.

» I, » 2 H. J. HANSEN: Experimental determination of the relation between the freezing point of seawater and its specific gravity at 0° C. 1904. 10 p.

» I, » 3 N. BJERRUM: On the determination of Chlorine in sea-water and examination of the accuracy with which Knudsen's pipette measures a volume of sea-water. 1904. 11 p. Kr. 1.25.

» I, » 4 J. N. NIELSEN: Hydrography of the waters by the Faroe Islands and Iceland during the cruises of the Danish research steamer "Thor" in the summer 1903. 8 Plates. 1904. 29 p.

» I, » 5 NIELS BJERRUM: On the determination of Oxygen in sea-water. 1904. 13 p. Kr. 3.50.

» I, » 6 MARTIN KNUDSEN: Contribution to the Hydrography of the North Atlantic Ocean. 21 Plates. 13 p. Kr. 5.75.

» I, » 7 J. N. NIELSEN: Contributions to the Hydrography of the waters north of Iceland. 2 Plates. 28 p.

» I, » 8 J. P. JACOBSEN: Die Löslichkeit von Sauerstoff im Meerwasser durch Winklers Titriermethode bestimmt. 1905. 13 S. Kr. 2.00.

» I, » 9 J. N. NIELSEN: Contribution to the Hydrography of the north-eastern part of the Atlantic Ocean. 3 Plates. 1907. 25 p. Kr. 1.75.

» I, » 10 J. P. JACOBSEN: Mittelwerte von Temperatur und Salzgehalt. Bearbeitet nach hydrographischen Beobachtungen in dänischen Gewässern 1880—1907. 11 Tafeln. 1908. 28 S. Kr. 3.50.

» I, » 11 J. N. NIELSEN: Contribution to the understanding of the currents in the northern part of the Atlantic Ocean. 1 Plate. 1908. 15 p. Kr. 0.75.

» I, » 12 J. P. JACOBSEN: Der Sauerstoffgehalt des Meereswassers in den dänischen Gewässern innerhalb Skagens. 5 Tafeln. 1908. 23 S. Kr. 2.00.

Bd. I, Nr. 13 KIRSTINE SMITH: Gezeitenstroeme bei den Feurschiffen Vyl und Horns Rev. Mit 4 Textfiguren. 1910. 23 S. Kr. 0.75.

» I, » 14 J. P. JACOBSEN: Gezeitenstroeme und resultierende Stroeme im Grossen Belt in verschiedenen Tiefen im Monat Juni 1909. Mit 7 Figuren im Text. 1910. 19 S. Kr. 0.75.

» II, » 1 MARTIN KNUDSEN: Danish hydrographical investigations at the Faroe Islands in the spring of 1910. 2 Plates. 1911. 17 p. Kr. 1.00.

» II, » 2 J. P. JACOBSEN: Beitrag zur Hydrographie der dänischen Gewässer. 47 Tabellen. 17 Textfiguren, 14 Tafeln. 1913. 94 S. Kr. 6.50.

» II, » 3 J. P. JACOBSEN: Strommessungen in der Tiefe in dänischen Gewässern in den Jahren 1909—1910 und 1911. Mittlere Werte des Stroms und Konstanten der Gezeitenbewegung. 1913. 43 S. Kr. 1.25.

» II, » 4 J. P. JACOBSEN: Hydrographical investigations in Faeroe Waters in 1913. 15 Fig. 1915. 47 p. Kr. 1.50.

» II, » 5 J. P. JACOBSEN: Contribution to the Hydrography of the Atlantic. 7 Fig. 8 diagrams. 1916. 24 p. Kr. 0.75.

» II, » 6 TH. P. FUNDER: Hydrographic investigations from the Danish School Ship "Viking" in the Southern Atlantic and Pacific in 1913—14. 1916. 28 p. Kr. 1.00.

» II, » 7 J. P. JACOBSEN: Hydrographische Untersuchungen im Randers Fjord (Jylland). 1918. 46 S. Kr. 2.50.

» II, » 8 Current Measurements from Danish Lightships. 1923. 78 p. Kr. 5.50.

» II, » 9 J. P. JACOBSEN: Die Wasserumsetzung durch den Öresund, den grossen und den kleinen Belt. 1925. 20 + VII Tab. 72 S. Kr. 5.00.

» II, » 10 BAGGESGAARD-RASMUSSEN and J. P. JACOBSEN: Contribution to the Hydrography of the Waters round Greenland in the Year 1925. 25 Fig. 1930. 24 p. Kr. 2.00.

The name: „Kommissionen for Havundersøgelser" has from the 1st of September 1926 been changed to: „Kommissionen for Danmarks Fiskeri- og Havundersøgelser".

Meddelelser fra Kommissionen for Danmarks Fiskeri- og Havundersøgelser

Bd. III, Nr. 1. J. P. JACOBSEN: Temperaturmessung mit elektrischem Widerstandsthermometer auf der Kattegatsexpedition im August 1931. 7 Fig. 1935. 22 p. Kr. 1.60.

Bd. III, Nr. 2. AAGE J. C. JENSEN: The Influence of the Currents in the Danish Waters on the Surface Temperature in Winter, and on the Winter Temperature of the Air. 14 Fig. 1940. 52 p. Kr. 3.00.

Serie: Fiskeri
„ : Plankton } see cover of these publications.

SKRIFTER UDGIVNE AF KOMMISSIONEN

Nr. 1 JOHS. SCHMIDT: Fiskeriundersøgelser ved Island og Færøerne i Sommeren 1903. 10 Tavler. 1904. VI + 148 S. Kr. 5.00. Udsolgt.

» 2 MARTIN KNUDSEN: Havets Naturlære. Hydrografi. Med særligt Hensyn til de danske Farvande. 10 Figurer, 4 Tavler. 1905. 41 S. Kr. 1.75. Udsolgt.

» 3 JOHAN HJORT og C. G. JOH. PETERSEN: Kort Oversigt over de internationale Fiskeriundersøgelsers Resultater med særligt Henblik paa norske og danske Forhold. 10 Tavler. 1905. 54 S. Kr. 3.50.

» 4 MARTIN KNUDSEN, C. G. JOH. PETERSEN, C. F. DRECHSEL, C. H. OSTENFELD: De internationale Havundersøgelser 1902—07. 1908. 28 S. Kr. 0,75.

» 5 BJARNI SÆMUNDSSON: Oversigt over Islands Fiske med Oplysning om deres Forekomst, vigtigste biologiske Forhold og økonomiske Betydning. 1 Kort. 1909. 140 S. Kr. 2.25.

» 6 ANDREAS OTTERSTRØM: Sildens Afhængighed af forskellige hydrografiske og meteorologiske Forhold i Store Bælt. 2 Textfigurer. 1910. 52 S. Kr. 1.00.

Nr. 7 A. C. JOHANSEN: Om Rødspætten og Rødspættefiskeriet i Beltfarvandet med nogle Bemærkninger om de øvrige Flynderarter og Flynderfiskerier i samme Farvand. 23 Tavler, 14 Textfigurer. 1912. 158 S. Kr. 3.00.

» 8 JOHS. SCMHIDT: Danske Undersøgelser i Atlanterhavet og Middelhavet over Ferskvandsaalens Biologi. 3 Tavler, 5 Textfigurer. 1912. 33 S. Kr. 1.50.

» 9 A. C. JOHANSEN og J. CHR. LØFTING: Om Fiskebestanden og Fiskeriet i Gudenaaens nedre Løb og Randers Fjord. — With an English Resumé. 4 Tavler. 42 Textfigurer. 1919. 169 S. Kr. 3.75.

» 10 ERIK M. POULSEN: Om Hummeren og Hummerfiskeriet i de danske Farvande. 6 Textfigurer. 1927. 42 S. Kr. 1.00.

» 11 ERIK M. POULSEN: Om Limfjordens Torskebestand. With an English Summary. 21 Figurer. 5 Tavler. 1942. 136 S. Kr. 4.50.

Notice:

It is requested that notice of any error in address or other communications concerning mailing etc. of this publication is sent to: Marinbiologisk Laboratorium, Charlottenlund Slot, Charlottenlund.

A complete list of the subjects included in the finished volumes will be furnished on application.